TULASNELLACEAE OF TAHITI. A REVISION OF THE FAMILY

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(WITH 38 FIGURES)

TAHITIAN TULASNELLACEAE

During a recent survey of the lower basidiomycetes of the Society Islands, five different species belonging to the Tulasnellaceae were found in Tahiti and the nearby island of Moorea, two of them not previously described so far as can be determined. Under the present system of classification (Rogers, **1933**), which has been until now accepted by the writer, the two new species, which are soft-gelatinous and produce glococystidia, would be placed in the genus *Glocotulasnella*. But, for reasons which will be made apparent in the latter part of this paper, only one genus—*Tulasnella*—is recognized in the Tulasnellaceae, and both new species are relegated to it.

T. VIOLEA (Quél.) Bourd. & Galz., Bull. Soc. Myc. Fr. **25**: 31. 1909.

This fungus typically produces thin, waxy-gelatinous, lilaceous fructifications. The spores of the first collection were measured and were found to be mostly around 4 × 5.5 μ, which is well within the dimensions considered characteristic of the species. It has previously been reported from the tropics by Martin (**1939**), who found it in Colombia.

Collected twice in Tahiti, once on an old thelephoraceous fungus and rotting wood, Fautaua Valley, Pirae District, April 8, 1956 (T119); again on rotting decorticate wood of *Hibiscus tiliaceus*, Punaauia District, July 16, 1956 (T421).

T. BIFRONS Bourd. & Galz., Bull. Soc. Myc. Fr. **39**: 264. 1923.

Two collections of this species were obtained. In both, the fructifications were very thin and grayish white in color. One collection (T202) has soft-waxy fructifications, but the other is too thin to permit a determination of its texture. The spores are oblong to short-cylindric

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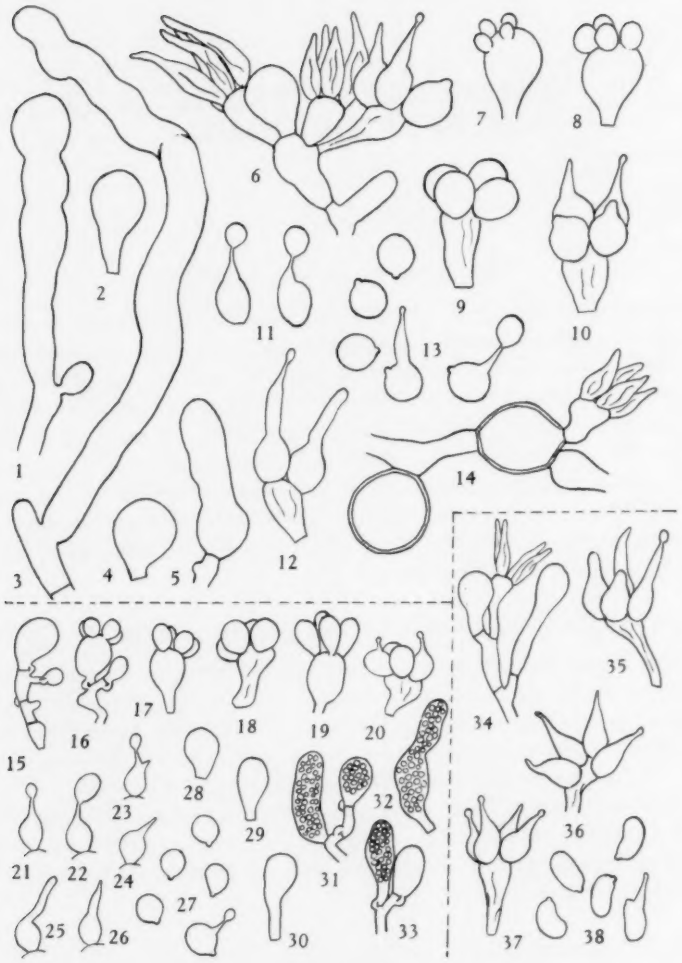

FIGS. 1–38.

FIGS. 1–14. *Tulasnella pacifica*. 1–5. Gloeocystidia. 6. Cluster of basidia. 7–10. Basidial development. 11. Protosterigmata with more or less subulate extensions. 12. Protosterigmata with filamentous sporogenous extensions. 13. Basidiospores, two germinating by repetition. 14. Chlamydospore-like cells. FIGS. 15–33. *Tulasnella guttulata*. 15–20. Stages in basidial development. 21–24. Protosterigmata with subulate sporogenous extensions. 25, 26. Protosterigmata with fila-

and may be flattened on one side or slightly curved. They measure 3–4 × 5–7.2 μ.

On decorticate rotting wood of *Hibiscus tiliaceus,* Afareaitu District, Moorea, April 19, 1956 (T202); on rotten wood of *Acacia,* Punaauia District, Tahiti, June 9, 1956 (T319).

T. caroliniana (Olive) comb. nov. (FIGS. 34–38)

Gloeotulasnella caroliniana Olive, Bull. Torrey Bot. Club **80**: 41. 1953.

This species was originally described from material collected in North Carolina. The single collection from Tahiti does not differ in any significant detail from the type material. In general appearance, texture, and internal structure it most closely resembles *T. pinicola* Bres., but its basidiospores are curved-cylindric instead of subglobose to ovate, and there are differences in microdimensions. A brief description of the Tahiti collections follows:

Fructification soft mucous-gelatinous, surface uneven, color sordid tan, drying to an invisible film. Hyphae relatively broad, 1.4–5.4 μ diam., basidial hyphae upright, often bearing numerous collapsed basidia below the younger ones; basidia typically pyriform to clavate-capitate, frequently with slender stalk-like base, 5–7 × 9–19.8 μ; protosterigmata 4, subglobose to oblong or pyriform, 3.6–4.6 × 4.5–7.2 μ, producing basidiospores on subulate extensions or on the tapered tips of cylindric, filamentous extensions; basidiospores curved-cylindric, apiculate, 3.2–4.1 × 6.8–9 μ.

On rotting decorticate wood, Hitiaa District, Tahiti, April 15, 1956 (T169).

It is quite common to find the basidiospores arising from directly tapered, subulate apices of the protosterigmata, although they also commonly arise from the tapered tips of filamentous extensions of the protosterigmata.

T. pacifica sp. nov. (FIGS. 1–14)

Fructificationes molliter gelatinosae vel mucoso-gelatinosae, alutaceae, tenues. Hyphae enodosae, frequenter crassae, 1.8–11.3 μ diam.; gloeocystidia sparsa, irregu-

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mentous extensions. 27. Basidiospores, one germinating by repetition. 28–30. Gloeocystidia with homogeneous contents. 31–33. Guttulate gloeocystidia. FIGS. 34–38. *Tulasnella caroliniana.* 34–37. Stages in basidial development. 38. Basidiospores, one germinating by repetition. (All figs. × 925.)

lariter subcylindracea, frequenter semel iterumve inflata, pallide lutescentes, 6.8–10.6 × 22.5–162 μ; basidia subglobosa, pyriformia, vel stipitata capitataque, 9–11.5 × 11.3–20.7 μ; protosterigmatibus typice quattuor, filamenta sporogena long. varia producentibus vel in apicem sporogenam directe attenuatis, 6.3–8.6 × 8.1–11.7 μ; basidiosporae subglobosae vel late ovate, minute apiculatae, 5.4–8.1 × 6.8–9.5 μ, per repetitionem germinantes.

Fructifications soft-gelatinous to mucous-gelatinous, tan, thin, surface uneven, up to 8 cm in length, drying invisible or nearly so. Hyphae without clamp connections, often very broad, 1.8–11.3 μ diam., swollen chlamydospore-like cells present or absent; gloeocystidia rather sparse, irregularly cylindric, often with one or more swellings, at first hyaline then pale yellow, 6.8–10.6 × 22.5–162 μ; basidia subglobose to pyriform or stalked and capitate, 9–11.5 × 11.3–20.7 μ; protosterigmata 4, subglobose, obovate, or oblong, producing cylindric sporogenous filaments of variable length or occasionally tapering directly to the spore, 6.3–8.6 × 8.1–11.7 μ, basidiospores subglobose to broadly ovate, minutely apiculate, 5.4–8.1 × 6.8–9.5 μ, germinating by repetition.

Three collections on dead wood of *Hibiscus tiliaceus,* Paea District, July 5, 1956 (T406, type; T407, co-type); Punaauia District, July 10, 1956 (T412).

T. pacifica is probably most closely related to *G. hyalina,* which it resembles in many of its microscopic features. It differs from the latter in its generally larger microdimensions, fewer gloeocystidia that show a greater variability in size and shape, and the large chlamydospore-like cells that appear in some material. The gloeocystdia of *T. pacifica* reach a length of 162 μ, whereas the maximum length recorded for *G. hyalina* is 63 μ (Olive, **1954**).

The large chlamydospore-like cells (FIG. 14) were observed in only one (T407) of the three collections of *T. pacifica.*

T. guttulata sp. nov. (FIGS. 15–33)

Fructificationes molliter gelatinosae vel mucoso-gelatinosae, tenues, hebeter alutaceae. Hyphae, nodosae-septatae, 1–2.5 μ diam.; gloeocystidia cylindracea, obovata vel clavato-capitata, guttulis hyalinis vel materia homogenea lutescenti suffulta, 5.5–9 × 9–28 μ; basidia obovata vel pyriformia vel clavato-capitata, 4.5–6.3 × 9–12.6 μ; protosterigmata quattuor, 4.2–5.2 × 6.3–8.1 μ, pro usu prolongationem sporogenam strictum subulatam, vel varo sporogenam filamentam producentibus; basidiosporae subglobosae vel ovoideae, apiculatae, 3.8–5.2 × 5–6.3 μ, per repetitionem germinantes.

Fructifications thin, soft-gelatinous to mucous-gelatinous, dull tan, with uneven surface, 10 cm or more in length, drying to an inconspicuous film. Hyphae with clamp connections, 1–2.5 μ diam.; gloeocystidia cy-

lindric, often irregularly so, or obovate to clavate-capitate and intergrading with the basidia in size and shape, with or without stalk-like base, filled with colorless droplets and remaining hyaline, or containing homogeneous contents that gradually become yellowish, 5.5–9 × 9–28 μ; basidia variable in shape, obovate to pyriform or clavate-capitate, 4.5–6.3 × 9–12.6 μ; protosterigmata 4, broadly obovate to oblong-obovate, 4.2–5.2 × 6.3–8.1 μ, producing narrow subulate sporogenous extensions that taper from base to apex, or more rarely producing elongate cylindric sporogenous filaments that taper abruptly at the apex; basidiospores subglobose to ovoid, apiculate, 3.8–5.2 × 5–6.3 μ, germinating by repetition.

On dead wood, Paea District, Tahiti, July 5, 1956 (T404, type).

Rogers (**1933**) notes that the gelatinous members of the Tulasnellaceae are characterized by having protosterigmata that give rise to more or less elongate, cylindric sporogenous filaments. In *T. guttulata,* however, narrow subulate extensions predominate, while cylindric filaments are much less common. The species shows certain affinities with *Gloeotulasnella hyalina* von Höhn. & Litsch., but an examination of type material in the Farlow collections reveals important differences in microdimensions, gloeocystidial characters, and development of the protosterigmata, which in *G. hyalina* give rise to relatively broad cylindric filaments.

Three other species of *Tulasnella* have been reported in the tropics; namely, *T. sphaerospora* Martin (**1939**) in Panama and *T. allantospora* Wakef. & Pears. from the Marshall Islands and *T. calospora* (Boud.) Juel from Hawaii (Rogers, **1947**).

REVISION OF THE TULASNELLACEAE

In this and a previous paper (**1957**) the writer has adopted the term *protosterigma,* coined by Donk (**1954**) and further advocated by Talbot (**1954**) to define any basidial extension intervening between the main part of the basidium (metabasidium) and the subulate spore-producing structure (spiculum) borne at its tip. In a number of heterobasidiomycetes and in hymenomycetes protosterigmata are lacking and the spicules are borne directly on the metabasidium. In many heterobasidiomycetes, such as *Platygloea* and *Auricularia,* some cells of a basidium may produce protosterigmata with spicules while other cells of the same basidium produce only spicules. The length of a protosterigma is generally directly related to the distance it must grow to reach the surface of the gelatinous matrix, and if a basidial cell is at the surface of the matrix, it usually produces only a spicule. In all cases, the spicule produced alone and the protosterigma and spicule

together are considered variations of the same structure—the sterigma—and they may both be referred to by this general term.[2]

In the Tulasnellaceae the term protosterigma replaces the term "epibasidium" as used by Rogers (**1933**) in referring to the four sporoid structures budded out directly from the basidium. I have already (**1957**) discussed reasons for their being considered highly modified sterigmata and have also urged acceptance of the basidial terminology proposed by Talbot (**1954**) in preference to the confusing terminology of the Neuhoff school. Talbot's system gives careful consideration to homologies, while Neuhoff's frequently does not.

In the Tulasnellaceae the protosterigma during spore production may become prolonged into a cylindrical sporogenous extension terminated by a spiculum, or the spiculum, gradually attenuated from base to apex, may arise directly from the inflated protosterigma.

The historical background of the family has been adequately reviewed by Rogers (**1932, 1933**). He states that *Gloeotulasnella* was legally published by von Höhnel and Litschauer (**1908**) as a subgenus of *Tulasnella* Schroeter to accommodate two gloeocystidiate species and was raised to full generic rank by Bourdot & Galzin (**1909**). However, in his review of the confused procedure of publication of these two species by von Höhnel and Litschauer, Rogers believed that it was the intent of these authors to establish *Gloeotulasnella* as a genus, and he proceeded on this premise. Rogers also emended the genus to include all of the soft-gelatinous species with or without gloeocystidia and left what he considered to be the more waxy species in *Tulasnella*. He points out that there is a close relationship among the gelatinous species regardless of whether they possess gloeocystidia and that the presence or absence of these structures should not be used in making generic distinctions.

Rogers (**1933**) distinguished the genus *Gloeotulasnella* from *Tulasnella* on the following points: "texture of basidiocarp, which . . . in all the species placed in *Gloeotulasnella* is mucous-gelatinous, almost deliquescent; structure of basidiocarp, the basidia being borne on long, slender hyphae perpendicular to the substratum; form of basidium, the probasidium being typically a considerably elongated cell with subglobose summit and claviform stalk, and the epibasidia producing long, cylindric

[2] I have no objection to the term "epibasidium" in the revised sense recently proposed by Martin (**1957**), in which case it is generally interchangeable with the term protosterigma. However, in view of the fact that the term epibasidium is still denoed in its original sense by other proponents of the Neuhoff theory, its continued use in both senses would only compound the confusion.

rather than subulate filaments; and basidial cytology, the hypobasidium sometimes giving rise to more than four epibasidia, and thus showing evidence of the occurrence of a post-meiotic division here, but the epibasidia usually remaining uninucleate."

Since the appearance of Rogers's monograph, nine additional species (including those described for the first time in this paper) have been published, seven of these by the writer. The discovery of these new species, in addition to observations made by the writer on recent collections of several previously known species, has brought to light a great deal of new information which seriously challenges the advisability of maintaining two generic names for the Tulasnellaceae. In the following discussion the writer reexamines each of Rogers's reasons for considering *Gloeotulasnella* a genus distinct from *Tulasnella* and presents reasons for the contrary opinions adopted in this paper.

1. *Texture of the fructification.* In his key to the genera Rogers states that the fructifications of *Tulasnella* are waxy to arid-pruinose and that those of *Gloeotulasnella* are waxy-gelatinous to mucous, the basidia being embedded in a gelatinous matrix in the latter but not in the former. In the individual species descriptions it is noted that some species of *Tulasnella* may produce waxy-gelatinous fructifications and that certain species of *Gloeotulasnella* may produce gelatinous-waxy or even waxy fructifications. The writer (**1953**) recently found in North Carolina a specimen of *T. violea,* a species considered by Rogers as typical of the genus, which was considerably thicker than usual and which had the soft-gelatinous texture generally ascribed to *Gloeotulasnella.* Similarly, a specimen of *T. pruinosa* Bourd. & Galz. with soft-gelatinous to mucous-gelatinous fructifications was found in the same area (**1954**). With reference to *G. calospora* (Boud.) Rogers, it is noted by Rogers that "On the basis of texture alone most collections of this species would be placed in *Tulasnella.*" Texture is, therefore, an unreliable character in generic separation here, as has also proved to be the case in such genera, for example, as *Sebacina* of the Tremellaceae.

2. *Structure of the fructification.* Rogers notes that the basidia of *Gloeotulasnella* are borne on hyphae arranged perpendicularly to the substratum, in contrast to their origin from hyphae more or less parallel with the substratum in *Tulasnella.* However, the gelatinous fructifications of the two species of *Tulasnella*—*T. violea* and *T. pruinosa*—mentioned in the foregoing paragraph had their basidia borne on vertical hyphae. Rogers has also noted that some collections of *T. pruinosa* that he examined have "erect, repeatedly forking hyphae." It seems

likely that the development of vertically arranged hyphae in these specimens is directly associated with the thickness of the fructification.

3. *Form of the basidium.* Rogers states that the probasidium of *Gloeotulasnella* is typically elongate, with inflated apex and claviform stalk, and that the protosterigmata ("epibasidia") produce long, cylindric rather than subulate filaments. I find these characteristics to be extremely variable within species of both genera. As many of my illustrations show, basidial shape is much too variable within a single species to be seriously considered of taxonomic importance in separating genera. It may be admitted that the development of cylindric, sporogenous prolongations of the protosterigmata is more characteristic of the thicker gelatinous fructifications than of the thinner waxy ones. The gelatinous fructifications of *T. pruinosa* which I have examined contained protosterigmata that often developed in this manner. On the other hand, such development may be lacking in many of the protosterigmata of species generally considered as belonging to *Gloeotulasnella.* For example, the protosterigmata of the collections of *T. caroliniana* and of *T. pacifica* described in this paper, as well as those of *G. rogersii* Olive (**1951**) and *G. papillata* Olive (**1954**), may produce abruptly tapered spicules without intervening filaments, while in the same fructification protosterigmata with filamentous extensions are also present. In *T. guttulata,* which is soft-gelatinous and has gloeocystidia, the majority of protosterigmata produce their spores on subulate, often quite short, extensions. It is clear, therefore, that none of these basidial characters is sufficiently reliable for generic distinction.

4. *Basidial cytology.* Rogers (**1932**) studied the basidial cytology of several species of *Tulasnella* and one species of *Gloeotulasnella* (*G. pinicola*). He found that in all species two meiotic divisions occur in the basidium and a single nucleus migrates into each protosterigma. In the species of *Tulasnella* a mitotic division occurs in the protosterigma, but this division fails to occur in *G. pinicola.* The possibility of a third mitotic division in the basidium of the latter is deduced from the rather rare occurrence of more than four protosterigmata on some of the basidia (Rogers, **1933**). The occurrence of more than four protosterigmata on a basidium of *T. bifrons,* a waxy species, was also recorded by the writer (**1944**, fig. 20), and the phenomenon is therefore not limited to species assigned to *Gloeotulasnella.* Since only one species assigned to that genus by Rogers has been studied cytologically, it would not be safe to say that the cytological developments which he observed in that species are representative of the entire group of more gelatinous species. On the other hand, the occurrence of mitosis in the

protosterigma is, at most, of no more than secondary importance and is certainly not a very handy character in taxonomic studies.

In view of the above discussion, I have attempted to justify the following treatment in which the single genus *Tulasnella* is recognized in the Tulasnellaceae. For the purpose of convenience in identification, two subgenera are recognized: *Gloeotulasnella*, legally published by von Höhnel & Litschauer as a subgenus, according to Rogers, and containing only gloeocystidiate species; *Tulasnella* (the same as the generic name, in accordance with the Paris Code, Art. 22), containing the non-gloeocystidiate species and including the type species. In general, I have no strong convictions about the importance of gloeocystidia (or cystidia) in making generic distinctions but am inclined to agree with Rogers that the gloeocystidiate and non-gloeocystidiate gelatinous species of the Tulasnellaceae are frequently very similar in all other respects, and it does not seem to me advisable to elevate *Gloeotulasnella* to generic rank. In *T. pacifica* the gloeocystidia, though conspicuous, are relatively scarce. The transition from this to a non-gloeocystidiate species is a minor one. This system has already been followed with considerable success in such genera as *Sebacina* (McGuire, **1941**).[3]

TULASNELLA Schroeter, Cohn's Krypt.-Fl. Schles. **3**: 397. 1888

Fructifications arachnoid, waxy, waxy-gelatinous, mucous-gelatinous, or firm-gelatinous, typically thin, resupinate; metabasidium budding out four inflated protosterigmata which become cut off from the metabasidium by inconspicuous basal septa; protosterigmata producing the spore-forming spicules directly or at the ends of cylindric sporogenous filaments; basidiospores germinating by repetition, or occasionally by the production of small conidia. Occurring as saprophytes on dead wood, bark, plant debris, or old hymenophores of other basidiomycetes.

TYPE: *Tulasnella lilacina* Schroet.

KEY TO THE SUBGENERA

Fructifications arid-pruinose, waxy, or firm- to soft-gelatinous, gloeocystidia absent.....I. TULASNELLA

Fructifications gelatinous-waxy to mucous-gelatinous; gloeocystidia present.....II. GLOEOTULASNELLA

[3] I do not accept the recent treatment of *Sebacina* by Ervin (Mycologia **49**: 118–123. 1957), who divides the group into four genera. This matter will be discussed in greater detail in a later paper.

KEY TO THE SPECIES

I. Tulasnella

1. Fructifications typically waxy, occasionally soft-gelatinous....2
1. Fructifications typically soft-gelatinous (firmly gelatinous in *T. tremelloides*)..13
2. Spores globose, 8–12 μ diam....*T. sphaerospora*
2. Spores subglobose to fusiform or cylindric....3
3. Spores subglobose to oblong, length decidedly less than twice the breadth....4
3. Spores subcylindric to cylindric or fusiform, length nearly twice the breadth or greater....8
4. Fructifications pink or lilaceous; texture pruinose, waxy, or soft-gelatinous; spores subglobose to broadly ovate, 3–7.5 × 3.5–10 μ....*T. violea*
4. Fructifications whitish (rarely pinkish in *T. pruinosa*, which has ellipsoid or short-oblong spores)....5
5. Spores subglobose, 2.5–3.5 × 3–4 μ....*T. lactea*
5. Spores obovate to ellipsoid or oblong, larger....6
6. Spores typically ellipsoid or short-oblong and not over 6.5 μ in length (3–4 × 4.6–6.5 μ); texture varying from arachnoid to soft-gelatinous....*T. pruinosa*
6. Spores larger....7
7. Fructification typically thin and waxy-pruinose; spores 4–7.6 × 6.5–9.3 μ....*T. albida*
7. Fructification typically delicate and cobwebby; spores 3.6–5 × 5.6–8 μ....*T. araneosa*
8. Spores oblong to subcylindric, averaging slightly less than twice as long as broad, 2.8–5 × 5–7.8 μ....*T. bifrons*
8. Spore length averaging twice the breadth or more....9
9. Spores subfusiform, 3.9–7 × 9–16.3 μ....*T. violacea*
9. Spores allantoid or cylindric, often curved....10
10. Spores allantoid, not exceeding 10 μ in length, measuring 2.5–4.5 × 5.5–8(–10) μ; fructification pale gray to lilaceous....*T. allantospora*
10. Spores longer....11
11. Spores very variable in size and shape, 15–52 μ long; fructification gray, tan, or pinkish gray....*T. calospora*
11. Spores less variable, not exceeding 18 μ in length; fructification violaceous or pink....12
12. Spores evenly curved-cylindric, 3–4 × 9–15 μ....*T. rutilans*
12. Spores attenuated towards the apiculum, no more than slightly curved, 3–5 × 9–18 μ....*T. fuscoviolacea*
13. White clusters of large hymenial conidia present; basidiospores large, 9.1–10 × 12.2–14.5 μ....*T. conidiata*
13. Hymenial conidia not present....14
14. Probasidium with apical thickening which appears as an eccentric papillum on mature basidium; spores 3.8–4.8 × 6.5–9 μ....*T. papillata*
14. Probasidium without apical thickening....15
15. Spores subglobose to ovoid or oblong....16
15. Spores cylindric, straight or curved....18
16. Fructification thick, undulate-plicate, firm-gelatinous; spores 3.5–5.5 × 6–9(–10) μ....*T. tremelloides*
16. Fructifications thinner, soft-gelatinous....17

17. Spores 4–6 × 6–10 μ.....*T. pinicola*
17. Spores 5–8 × 7–14 μ.....*T. griseo-rubella*
18. Spores slightly curved-cylindric, 3–4.5 × 8.3–10.8 μ.....*T. caroliniana*
18. Spores straight to conspicuously curved, sometimes sigmoid or helical, 3–4 × 15–52 μ.....*T. calospora*

II. Gloeotulasnella

1. Spores allantoid.....2
1. Spores subglobose to ellipsoid or short-oblong.....3
2. Gloeocystidia aggregated into groups, hyaline or nearly so; spores 3–3.8 × 6.7–9 μ.....*T. aggregata*
2. Gloeocystidia not aggregated, golden yellow; spores 2.6–3.4 × 6.1–8.8 μ.....*T. rogersii*
3. Gloeocystidia often exceeding 75 μ in length.....4
3. Gloeocystidia not exceeding 75 μ in length.....5
4. Gloeocystidia becoming filled with yellow, oily looking contents, 5–23 × 24.4–120(–210) μ; spores 3.5–5.8 × 4.5–7.8 μ.....*T. traumatica*
4. Gloeocystidia becoming pale yellow, 6.8–10.6 × 22.5–162 μ; spores 5.4–8.1 × 6.8–9.5 μ.....*T. pacifica*
5. Gloeocystidia very variable in size and shape, often with moniliform swellings; spores 4–7 × 4.5–9 μ.....*T. cystidiophora*
5. Gloeocystidia less variable, not moniliform.....6
6. Gloeocystidia often filled with hyaline droplets, others with light yellow homogeneous contents; spores 3.8–5.2 × 5–6.3 μ.....*T. guttulata*
6. Gloeocystidia typically with hyaline homogeneous contents that become pale yellow; spores 4.5–8 × 4.5–9 μ.....*T. hyalina*

Unfortunately several species, particularly of the subgenus *Tulasnella*, are poorly known, and several that appear to be difficult to separate in the key may be later found to represent different forms of the same species. For descriptions and synonymy of species described prior to 1933, the reader is referred to Rogers's monograph of the Tulasnellaceae. A few additional notes on some of these species, new distributional records, and notes on more recently described species are included below.

T. SPHAEROSPORA Martin, Mycologia **31**: 242. 1939

The species is characterized by its waxy, pink fructifications, globose, stalked probasidia, and globose spores.

Distribution: Known only from type locality, Panama.

T. VIOLEA (Quél.) Bourd. & Galz.

Typically pinkish, pruinose to waxy-gelatinous, but occasionally soft gelatinous and then with vertical development of basidial hyphae. Rogers considers the type species, *T. lilacina*, as a synonym of *T. violea*.

Distribution: Widespread in Europe and North America, also in Colombia and Tahiti.

T. LACTEA Bourd. & Galz.

This is the smallest-spored species in the genus. The spores are subglobose and measure 2.5–3.5 × 3–4 μ.

Distribution: Europe; United States (Iowa, Missouri).

T. PRUINOSA Bourd. & Galz.

Two collections have been reported recently from North Carolina (Olive, **1954**), one with waxy-gelatinous fructifications and the other with soft-gelatinous to mucous-gelatinous fructifications and protosterigmata that frequently produce cylindric sporogenous filaments. In the latter collection there is also a well-developed system of vertical basidium-bearing hyphae.

Distribution: Europe; Ontario; United States (Ohio, Wisconsin, Iowa, North Carolina).

T. ALBIDA Bourd. & Galz.

My collection (**1944**) of this species had thin, soft-waxy fructifications with subglobose to obovate probasidia, frequently with slender stalk, and subglobose to short-elliptic basidiospores, often flattened on one side and measuring 5.3–7.6 × 7.6–9.3 μ.

Distribution: France; United States (North Carolina).

T. ARANEOSA Bourd. & Galz.

As Rogers has noted, *T. araneosa* is not readily distinguished from *T. albida*. A recent collection of mine from North Carolina, tentatively assigned to *T. araneosa*, has very thin, light gray, cobwebby fructifications and basidiospores that are slightly depressed on one side and measure 3.6–4.5 × 5.6–7.2 μ. In view of the differences between this and the collection of *T. albida* from North Carolina, I have decided to treat these as closely related species, although it is quite possible that they are only variants of the same species. *T. bifrons* belongs in the same category, as it is not readily separable from these two species.

T. BIFRONS Bourd. & Galz.

The fructifications are soft-waxy, usually grayish-white, but occasionally pale lilaceous. A collection from North Carolina (Olive, **1944**) produced a pink spore print.

Distribution: Europe; Canada; United States (Ohio, Iowa, New England, Missouri, North Carolina); Moorea and Tahiti of French Polynesia.

T. VIOLACEA (Johan-Olsen) Juel

Distribution: Widespread in Europe and North America, also in the Marshall Islands.

T. ALLANTOSPORA Wakef. & Pears.

Distribution: Europe; Ontario; United States (Ohio, Iowa, Missouri, Massachusetts, New York, North Carolina); Marshall Islands.

T. FUSCOVIOLACEA Bres.

Distribution: Europe; Ontario; United States (Ohio, Iowa, Minnesota, New Hampshire, New York).

T. RUTILANS (Johan-Olsen) Bres.

There is some question as to whether this species is distinct from *T. fuscoviolacea,* which in turn is not always easily separated from *T. violacea.* According to Rogers, *T. rutilans* may be distinguished from *T. fuscoviolacea* on the basis of its evenly curved, *Exidia*-like basidiospores, the latter having only slightly curved spores of less uniform diameter.

Distribution: Europe; United States (Iowa).

T. conidiata sp. nov.

Tenuis, mucoso-gelatinosa, hyalina. Hyphae nodoso-septatae; conidia in massulis visibilibus, sparsis, albis, 9.2–12.2 × 21.4–33.6 μ; basidia plerumque clavata, 9.2–15.3 × 22.9–29 μ; protosterigmatibus ovatis vel pyriformibus, 8.4–11 × 10.7–18.3 μ, filamenta sporogena long. variabilia producentibus; basidiosporae subglobosae vel oblongae, uno latere applanatae, apiculatae, 9.1–10 × 12.2–14.5 μ, per repetitionem vel nonnumquam per conidia parva sphaerica gemmiformia germinantes.

Fructification thin, mucous-gelatinous, watery white. Hyphae with clamp connections; conidia in distinct, scattered white masses, 9.2–12.2 × 21.4–33.6 μ; basidia typically clavate, 9.2–15.3 × 22.9–29 μ; protosterigmata oblong to pyriform, 8.4–11 × 10.7–18.3 μ, producing sporogenous filaments of variable length; basidiospores subglobose to oblong and flattened on one side, apiculate, 9.1–10 × 12.2–14.5 μ, germinating by repetition or occasionally budding out small spherical conidia.

This was published by the writer (**1944**) as *Gloeotulasnella cystidiocarpa*, a misleading name based upon the mistaken assumption that the conidia were gloeocystidia. That they are large conidia, probably binucleate ones, is evidenced by the fact that they readily germinate to produce hyphae with clamp connections. Since the original description was not published in Latin it is not necessary to retain the former name, and the species is hereby published under a more appropriate specific epithet.

Distribution: Known only from the type locality, Chapel Hill, North Carolina.

T. papillata (Olive) comb. nov.

Gloeotulasnella papillata Olive, Bull. Torrey Bot. Club **81**: 335. 1954.

The development of a thickened apical papillum on the probasidium, which later assumes an eccentric position on the metabasidium, distinguishes this fungus from all previously described species.

Distribution: Known only from the type locality, Highlands, North Carolina.

T. caroliniana (Olive) comb. nov.

Gloeotulasnella caroliniana Olive, Bull. Torrey Bot. Club **80**: 41. 1953.

The allantoid spores distinguish this fungus from other soft-gelatinous species lacking gloeocystidia. It is strange that the species, which appears to be uncommon, has been found in two widely varied localities.

Distribution: North Carolina; Tahiti.

T. CALOSPORA (Boud.) Juel.

Rogers notes that most collections of this species are waxy to gelatinous-waxy but includes it in the genus *Gloeotulasnella* in his monograph. A collection described by the writer (**1946**) had soft-gelatinous fructifications.

Distribution: Europe; Hawaii; Ontario; United States (Iowa, Maine, North Carolina, Oregon).

T. TREMELLOIDES Wakef. & Pears.

This species is unusual in having thick, undulate-plicate, firm-gelatinous fructifications that are deep purple in color. It appears to be uncommon.

Distribution: England; United States (Iowa).

T. PINICOLA Bres.

This is one of the most widespread and common species. It grows on decaying bark and wood of both coniferous and frondose trees and over the surface of old sporophores of hymenomycetes.

Distribution: Europe; Hawaii; Ontario; United States (Wyoming, Ohio, Minnesota, Iowa, New England, New York, North Carolina, Georgia, Louisiana).

T. GRISEO-RUBELLA Litsch., Svensk Bot. Tidsk. **26**: 448. 1933.

There is some question as to whether this species is distinct from *T. pinicola*. Litschauer states that it is not so thick or dark in color as *T. pinicola* and that the spores are larger (but they are not conspicuously so).

Distribution: Reported once from Sweden.

T. aggregata (Olive) comb. nov.

Gloeotulasnella aggregata Olive, Bull. Torrey Bot. Club **80**: 40. 1953.

The closest relative of this species is probably *T. rogersii*, from which it may be readily distinguished by its pale gloeocystidia, which are aggregated into groups. These two are the only gloeocystidiate species known to have allantoid spores.

Distribution: Known only from the type locality, Highlands, North Carolina.

T. rogersii (Olive) comb. nov.

Gloeotulasnella rogersii Olive, Mycologia **43**: 688. 1951.

Distribution: Collected twice in Louisiana.

T. traumatica (Bourd. & Galz.) comb. nov.

Gloeotulasnella traumatica Bourd. & Galz. Bull. Soc. Myc. Fr. **25**: 32. 1909.

G. opalea Rogers, Ann. Mycol. **31**: 198. 1933.

The fructifications vary from waxy-gelatinous to tough-mucous or mucous. The species is distinguished primarily by its large gloeocystidia with yellow, oily looking contents. It may be distinguished from *T. pacifica*, described in the first part of this paper, on the basis of its deeper yellow, typically broader and more abundant gloeocystidia and its somewhat smaller spores.

Distribution: Europe; Ontario; United States (Iowa and North Carolina).

T. CYSTIDIOPHORA v. Höhn. & Litsch. apud Saccardo, Syll. Fung. **21**: 453. 1912.

Gloeotulasnella cystidiophora v. Höhn. & Litsch. apud Rogers, Ann. Mycol. **31**: 195. 1933.

The long, irregular, yellow gloeocystidia, which are frequently moniliform in appearance, distinguish the species from all others.

Distribution: Europe; Ontario; United States (Iowa, Massachusetts, North Carolina).

T. HYALINA v. Höhn. & Litsch. apud Saccardo, Syll. Fung. **21**: 453. 1912.

Gloeostulasnella hyalina v. Höhn. & Litsch. apud Rogers, Ann. Mycol. **31**: 196. 1933.

G. metachroa Bourd. & Galz., Bull. Soc. Myc. Fr. **39**: 265. 1924.

There appears to be no important feature by which one may distinguish the Bourdot and Galzin species from *T. hyalina*. Rogers separates the two in his key on the basis that the hyphae of *T. hyalina* are without clamp connections, while those of *G. metachroa* possess clamps. In a reexamination of type material of *T. hyalina* in the Farlow collections, the writer found abundant clamps on the hyphae. A collection of *T. hyalina* from North Carolina (Olive, **1954**), on the other hand, was found to be devoid of clamp connections. As has been previously noted by several investigators, the presence or absence of clamp connections can hardly be used as a primary diagnostic character.

The characteristics of the North Carolina collection agree well with those of the type. My microdimensions for the latter are as follows: hyphae 2.7–6.3(–8.6) μ broad; gloeocystidia 6–9.5 × 17–45 μ; basidiospores 5.4–7.6 × 6.3–9 μ. Although the gloeocystidia have been described as hyaline, they were found to become very pale yellow in both the type material and in the North Carolina collection. Von Höhnel and Litschauer state that some of the gloeocystidia contain numerous minute oil droplets, but such gloeocystidia were not observed by me in either the type material or the North Carolina collection. Probably the species most closely related to *T. hyalina* is *T. pacifica*, described in the first part of this paper.

Distribution: Europe; United States (North Carolina).

I am grateful to Dr. D. P. Rogers for preparation of the Latin descriptions. Type material of the new species has been deposited in the mycological collections of the New York Botanical Garden.

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THE POROTHELEACEAE: POROTHELEUM

WM. BRIDGE COOKE [1]

The family *Porotheliaceae* was proposed by Murrill (**1916**) for the genus *Porotheleum* (spelled *Porothelium* by him). Since the subiculum and its degree of development are the only characteristics which separate this genus from *Solenia* and *Phaesolenia*, it is thought preferable to use *Porotheleaceae* for the cyphelloid fungi rather than to legitimize the name "*Cyphellaceae*" which appears to have been used first by Pilát (**1924**) as a descriptive term in a species list.

Porotheleum is distinguished from *Solenia* on the basis of subiculum development. In earlier studies on this complex, *Cyphella* and *Solenia* were largely separated on the basis of a lack of subiculum hyphae in the former. However, a study of a large series of specimens has made this appear to be an unrealistic basis for separation. As will be described in a forthcoming paper, *Solenia* includes species with cupulate to tubular receptacles which originate on the substratum and may or may not be surrounded by subicular hyphae, while *Porotheleum* includes cupulate to rarely tubular receptacles which originate on the thin to rather thick membranous subiculum. This distinction is not considered strong enough to warrant separation of fungi showing the two types of receptacle development into separate families. On the other hand, the development of the receptacles in *Fistulina* is considered sufficiently distinct to retain the family *Fistulinaceae*.

The receptacles of *Solenia* and *Porotheleum* are very similar in anatomy. In all specimens examined, the hyphae and tissue systems are monomitic. The receptacle wall is relatively thin, giving rise on the inside to the subhymenium and hymenium tissues in which sterile structures are rarely present, and on the outside to the sterile surface hyphae which may be undifferentiated or differentiated into special hyphal webs or surface hairs which envelope the receptacle with hyphae similar to those of the subiculum.

This report is based on the examination of 393 specimens of fungi included in the genus, found in herbaria in North America and else-

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where. Most specimens were deposited under the name *Porothelium*, but *Cyphella* and *Solenia* were also used.

Of these specimens 93% fall in three species (*P. revivescens, P. poriaeformis,* and *P. fimbriatum*), the remaining 7% are placed in 7 species, of which 4 are represented by only one collection each. *P. revivescens* is found in 12 collections from only three islands in the Caribbean. *P. poriaeformis,* of which 138 specimens have been studied, has been found on a wide variety of hosts throughout the world. Its appearance at various stages of its development, its occurrence on different hosts, and the infrequence of its occurrence in collections have led many mycologists to assume, each time it turns up, that a different species has been found. Thus 12 epithets in 31 different combinations have been used for it. Within its pattern of variation there are two types of spore shape, oval and subspherical. Insufficient material connecting the two types, beyond occasional receptacles carrying both types in the same collection, is available for adequately setting up two species based on this character. Finally, *P. fimbriatum,* represented by 227 specimens in the materials studied, occurs commonly throughout the northern hemisphere, has been found in Brazil and has been collected in 23 states in the United States. Both *P. revivescens* and *P. fimbriatum* are constant in character throughout their ranges.

POROTHELEACEAE Murr.

Mycologia **8**: 56. 1916 (as *Porotheliaceae*)

Receptacles cup-shaped to tubular, seated directly on the substratum, with or without an associated subiculum, or seated on or in a membranous to coriaceous subiculum; hymenium rarely with special structures other than basidia.

Type genus: *Porotheleum* (Pers. ex Fr.) Fr.

Since I have decided to remove fungi with cupulate receptacles and simple hymenia from the *Thelephoraceae,* a family name must be chosen for the group. Murrill established the name *Porotheliaceae* specifically for the genus *Porotheleum.* Although this genus makes up only a very small part of the fungi treated here and although the subicular habit upon which it is based is rare in the group, considering the number of species treated, this name is retained for the family.

The use of the name *Cyphellaceae* has never been completely validated. Pilát used it in several publications. The first one of these appeared in 1924 and others came out in 1925, 1936 and 1937. Patouillard established a tribe in the *Porohydneae* based on *Cyphella* in 1900,

and in 1928 Bourdot and Galzin followed him. Donk used the group as a subfamily of the *Aphyllophoraceae* in 1931. The group was not mentioned in his 1951 paper in which several families, including polyporaceous fungi, were established. However, in his treatment of the genera of the "Cyphellaceae," 1951, he indicated that the family was treated as an aggregate of genera rather than a taxonomic unit. The present treatment, it is felt, includes a more homogenous group of genera than earlier treatments discussed by Donk in his paper on the genera. The 94 species treated in *Solenia, Phaeosolenia, Leptotus* and *Chromocyphella* will be considered in a later paper.

POROTHELEUM (Pers. ex Fr.) Fr., Syst. Orb. Veg. 80. 1825 (not *Porothelium* Eschw. 1824. Lichenes)
Porotheleum Fr., Obs. Myc. **2**: 272. 1818
Polyporus Tribe *Porotheleum* Pers. ex Fr., Syst. Myc. **1**: 506. 1821
Stigmatolemma Kalchbr., Grev. **10**: 104. 1882
Stromatoscypha Donk, Reinwardtia **1**: 218. 1951

Fructification annual or perennial, formed by a thick membranous subiculum on or in which are seated numerous cup-shaped receptacles which arise as papillae and develop into independent fruit bodies whose walls may eventually become confluent and then the whole fructification assumes the aspect of a *Poria;* hymenium composed of basidia on each of which four hyaline or brown spores are produced.

Type: *P. fimbriatum* (Pers. ex Fr.) Fr.

Fries used the spelling *Porotheleum* in his earlier works until 1838. Following his usage of *Porothelium* in the Epicrisis apparently all workers have used the latter spelling. It is here proposed to return to the original spelling.

Donk (**1951**) established the genus *Stromatoscypha* for *Porotheleum* because he considered *Porotheleum* Fr. an orthographic variant of *Porothelium* Esch. *Porothelium* Esch., Syst. Lichen. 18, 1824, was established for three lichens for which no new combinations in the genus were made. According to the International Code (1952), Art. 82 states in part: "When two or more generic names are so similar, and the plants so closely related as to cause confusion, they are to be treated as variants of the same name." The two genera considered here are obviously not closely related and the lichen genus is a comparatively obscure one so that confusion could exist only in the case of a rare specimen. The presence of algal cells in one case would remove this source of confusion. Certainly, in routine examination of specimens it

is highly unlikely that a specimen from each genus would appear in the same lot of specimens. The ends *-ium* and *-eum* are not considered among those suggested as possible parallel endings in Recommendation 821 on page 46 of the Code. On these bases *Porotheleum* Fr. and *Porothelium* Esch. are considered different and *Stromatoscypha* Donk is considered superfluous.

Because Rick labeled a number of specimens of *Porotheleum poriaeformis "Theleporus cretaceus"* it was thought that this complex, treated below as subgenus *Stigmatolemma*, might better be named *Theleporus* rather than *Stigmatolemma*. Through the kindness of D. P. Rogers, a specimen (possibly the type) of *Theleporus cretaceous* from the Massee Herbarium obtained by E. Fries from Natal was observed. It is possible that this species has been collected only once. Doidge (**1950**) cites only one specimen: *Theleporus cretaceous* Fr. 1848: 10, in forest, Natal, Coll. Wahlberg, Type. The specimen in the Massee Herbarium (NY) may be a portion of this collection. This material is entirely different from *Porotheleum poriaeformis*. Patouillard (**1900**) considered *Theleporus* teratologic. Rick used the genus for *Stigmatolemma* specimens and said it was intermediate between *Solenia* and *Porotheleum*. The specimen at New York seems to be of a corticioid nature but, instead of a smooth hymenium, sterile tissue forms a network of tubules down the sides of which the hymenium descends somewhat; not, however, as in a true *Poria*. In a true *Poria* the hymenium originates from the dissepiments or tube trama; in *Theleporus* the hymenium appears to originate only from the stromatic tissues from which also arise the sterile tissues forming the walls of the false tubules. This is slightly different from the situation in *Porogramme*, in which sterile tissue also forms false tubules, although the hymenium does not appear to descend down the tube walls. Doidge (**1950**) placed *Theleporus* in the *Fistulinaceae*, indicating that she believed the cupules separate. Talbot (**1954**) considers the walls seen in *Porogramme* as elaborated hyphal pegs which have become developed in large numbers producing a pseudoporoid appearance. He does not mention *Theleporus*, which is similar.

KEY TO SUBGENERA OF POROTHELEUM

1. Spores hyaline, fructification usually appearing to be annual in development....2
1. Spores brown, subiculum pulvinate, appearing perennial in development..... ..... *Phaeoporotheleum*
2. Hyphae of subiculum hyaline to pale colored, without conspicuous granular incrustations..... *Porotheleum*
2. Hyphae brown, densely covered with large quantities of hyaline crystalline granules..... *Stigmatolemma*

Subgenus POROTHELEUM

Receptacles discoid, produced on a rather thick, whitish to cream-colored or tan subiculum, hyphae not incrusted.

Type species: *Porotheleum fimbriatum* (Pers. ex Fr.) Fr.

KEY TO SPECIES OF SUBGENUS POROTHELEUM

1. Spores globose, minutely verrucose, fructification pileate ..... *P. rugosum*
1. Spores ovate to cylindric, fructification resupinate 2
   2. Fructification perennial ..... *P. perenne*
   2. Fructification annual, not adding seasonal increments 3
3. Paraphysoid hairs present in the hymenium ..... *P. subiculosa*
3. Paraphysoid hairs absent 4
   4. Margin definite, spores 5–7 × 3–4 μ ..... *P. leucobombycinum*
   4. Margin fimbriate or lacerate, spores 3–5(–6) × 1.5–3 μ ..... *P. fimbriatum*

POROTHELEUM FIMBRIATUM (Pers. ex Fr.) Fr., Epicr. 503. 1838 (as *Porothelium*)

Poria fimbriata Pers., Neues Mag. Bot. **1**: 109. 1794
Boletus byssinus Schrad., Spic. **1**: 172. 1794
Boletus fimbriatus Pers., Syn. 546. 1801
Porotheleum fimbriatum Fr., Obs. Myc. **2**: 272. 1818
Porotheleum lacerum Fr., Obs. Myc. **2**: 273. 1818
Polyporus subtile (Schrad.) Fr., Syst. Myc. **1**: 506. 1821
Boletus pezizoides Schw., Schr. Nat. Ges. Leipzig **1**: 100. 1822
Porothelium friesii Mont., Ann. Sci. Nat. II. **5**: 339. 1836
Polyporus fatiscens Berk. & Br., Grev. **1**: 65. 1872
Porothelium hydnoideum Berk., Grev. **1**: 70. 1872
Poria fatiscens (Berk. & Br.) Cooke, Grev. **14**: 114. 1886
Porothelium vaillantii (Fr.) Quél., Enchir. Fung. 181. 1886
Porothelium subtile (Schrad. ex Fr.) Quél. Enchir. Fung. 181. 1886
Porothelium papillatum Pk., N. Y. St. Bot. Rept. **40**: 55. 1887
Poria fimbriata (Pers. ex Fr.) Pers. ex Lloyd, Myc. Writ. **5**: Myc. Notes **52**: 740. 1917
Stromatoscypha fimbriata (Pers. ex Fr.) Donk, Reinwardtia **1**: 219. 1951

Subiculum resupinate, thick, white at margin, cream toward center, with a fimbriate or lacerate margin, margin sterile, subiculum formed of tightly packed, hyaline, septate hyphae, rarely incrusted, arranged parallel to irregularly interwoven, 200–500 μ thick; clamps at base of basidia and on hyphae of subhymenium tissue, not seen on subiculum hyphae; receptacles at first papillate, papillae becoming punctate, super-

ficial to sunken, 300–1000 μ high, 300–1000 μ in diameter, opening into crowded, not confluent to somewhat or completely confluent cups, toward the margin 2–3 per mm, toward the center 4–5 per mm, fading to "Naples yellow," tan, brown or resinous brown; new papillae may be inserted among older cups; hymenium 20–25 μ thick, cream to brown in color; basidia 17–19 × 4.5–5.5 μ, 4-sterigmate, no cystidia found; spores hyaline, smooth, apiculate, ellipsoid, flattened on one side, 3–5(–6) × 1.5–3.5 μ.

Habitat: On rotten conifer and deciduous wood of at least: *Abies alba, A. siberica, Acer* sp., *A. saccharum, Aesculus* sp., *Alnus* sp., *Betula* sp., *B. alba, B. lutea, B. papyrifera, Carpinus betulus, Carya* sp., *Castanea dentata, Erica* sp., *Fagus* sp., *F. atropunica, F. grandifolia, Fraxinus* sp., *Larix* sp., *Liriodendron tulipifera, Lithocarpus densiflora, Ostrya* sp., *Pinus* sp., *P. strobus, Platanus* sp., *Populus* sp., *P. balsamifera, P. tremula, Pyrus malus, Quercus* sp., *Q. alba, Q. chrysolepis, Sorbus* sp., *Thuja occidentalis, Tsuga canadensis, Ulmus americanus.*

Collections examined from: Austria (6), Czechoslovakia (1), France (4), Germany (1), Great Britain (1), Luxembourg (1), Portugal (1), Russia (1), Sweden (11), Switzerland (1); Siberia (2); Brazil (1), Guadeloupe (1), Venezuela (3); Manitoba (3), Nova Scotia (3), Ontario (16), Prince Edward Island (1), Quebec (3); Alabama (4), California (4), Florida (4), Illinois (2), Indiana (1), Kentucky (3), Maine (7), Maryland (1), Massachusetts (1), Michigan (15), Missouri (2), New Hampshire (9), New York (61), North Carolina (5), Ohio (6), Pennsylvania (7), South Carolina (5), Tennessee (2), Vermont (11), Virginia (2), West Virginia (4), Wisconsin (8).

Type specimen examined:

Porotheleum papillatum Pk.: New York: Elizabethtown, Herb. Peck [NY, NFC]

Numbers of specimens from the political divisions mentioned above indicate that this species is more common than the number of synonyms, hosts, and collections indicate.

Porotheleum subiculosa L. O. Overholts, sp. nov.

Receptacula cylindracea, alba vel pallide lutea, dense gregaria; subiculo ad 500 μ crasso, hyphis hyalinis, 2 μ diam.; basidiis 14–18 × 3–4 μ, 4-sterigmaticis; sporis hyalinis, laevibus, apiculatis, ellipsoideis, 4–5 × 3 μ.

Receptacles cylindric, white to cream-color, densely gregarious, seated on a subiculum up to 500 μ thick; subiculum of more or less densely

interwoven, hyaline, non-staining hyphae 2 μ in diameter with occasional clamps; receptacles papillate at first, then tubular, tubes remaining distinct, smooth or somewhat mycelioid on the surface; basidia 14–18 × 3–4 μ, 4-sterigmate; clamps present in the subhymenial tissue; paraphysoid hairs elongate, hair-like, occasional, 45 × 3 μ; spores hyaline, smooth, apiculate, ellipsoid, 4–5 × 3 μ.

Habitat: On rotten wood of *Liquidambar styraciflua*.

Type and specimen examined: West Virginia: National, Nov. 16, 1933. Coll. C. R. Orton and A. R. Stanley. (LOO 13232.)

POROTHELEUM cubense Berk. & Curt., Journ. Linn. Soc. Lond. Bot. **10**: 323. 1869 (as *Porothelium*)

Fragment in packet obtained from Wright specimen by Weir in NFC shows scattered to gregarious cups with white subiculum between or around them; cups elongate, tubular, embedded in a loose subiculum.

Habitat: On dead wood.

Type specimen examined: Cuba: Wright, March 1857. Herb. Weir. (NFC, Pat in FH).

Collections examined from: Cuba (2), Ecuador (1), Brazil (1).

POROTHELEUM RUGOSUM Berk., in Hook, Journ. Bot. 1856: 237. 1856 (as *Porothelium*)

Fructification pileate, sessile, context pallid, tubes pallid, separated from the context by a definite line, surface with a crust, tubes densely packed together, more or less easily separable but not appearing to be produced separately; spores hyaline to yellow, globose, apiculate, minutely verrucose, 7–10.5 μ in diameter.

Habitat: On old wood.

Type and specimen examined: Brazil: Panuré. Bresadola Herb. (NFC).

Porotheleum leucobombycinum nom. nov.

Polyporus xylostromatoides Berk., Hook, Lond. Jour. Bot. **2**: 638. 1843

Poria xylostromatoides (Berk.) Cooke, Grevillea **14**: 11. 1886

Merulius xylstromaticus (Berk.) Rick, specimen at NFC, MO 74995

Receptacula 500 μ lata altavque; subiculo 0.5–1.0 mm crasso; hyphis hyalinis, 1.5–2 μ diam., flexuosis, incrustatis; basidiis 30 × 6–8 μ, 4-sterigmaticis; sporis hyalinis, levibus, apiculatis, ovatis, 5–7 × 3–4 μ.

Fructification consisting of a subiculum 0.5–1.0 mm thick, with a definite margin, in which the receptacles are sunken; subiculum hyphae hyaline, 1.5–2 μ in diameter, flexuous, loosely interwoven, with clamps, sometimes incrusted especially at or near the surface of the receptacles; receptacles 500 μ deep, 500 μ in diameter; basidia 4-sterigmate, 25–30 $\times$ 6–8 μ; spores hyaline, smooth, apiculate, ovate, 5–7 $\times$ 3–4 μ.

Habitat: On wood and on *Bambusa* sp.

Type: São Leopoldo, Rio Grande do Sol, Brazil. Coll. by J. Rick, 1932 (NFC).

Specimens examined: Paraguay (3), Brazil (1).

This species differs from *P. bombycinum* Speg. in the smooth, hyaline, ovate spores, and the large receptacles embedded in a clamped subiculum. Material of *Merulius xylostromaticus* (Berk.) Rick agrees with the type of this species but whether Berkeley had material like this at hand is uncertain.

Porotheleum perenne sp. nov.

Fructificatio perrenis, 500–1000 μ crassa, receptaculo 100–150 μ lato altoque, basidiis 10–14 $\times$ 2–3 μ; sporis hyalinis, ovatis, levibus, apiculatis, 2.5–5 $\times$ 1.5–3 μ.

Fructification of several layers, probably perennial, with at least four layers of subiculum, each layer 75–150 μ thick, on which are seated separate receptacles 100–150 μ deep, 100–150 μ in diameter, which become surrounded and covered by the subiculum of the oncoming season; current tube layer on the outer surface, the whole reaching 500–1000 μ thick; subiculum hyphae 2–3 μ in diameter, irregularly interwoven, with clamp connections; basidia 4-sterigmate, 10–14 $\times$ 2–3 μ; no sterile cells seen in hymenium except young basidia; spores hyaline, ovate, smooth, strongly apiculate, 2.5–5 $\times$ 1.5–3 μ.

Habitat: On rotten wood and on log of *Acer saccharum*.

Type: New York: Lake Placid, Adirondack Mountains, 2000 ft., July 17–19, 1912. Coll. W. A. & E. L. Murrill 47. (NY.)

Specimens examined from: New York (3).

Subgenus **Stigmatolemma** (Kalchbr.) comb. nov.

Stigmatolemma Kalchbr., Grev. **10**: 104. 1882

Receptacles discoid, produced on a rather thin, whitish to blackish subiculum, hyphae heavily incrusted with white granules.

Type: *Stigmatolemma incanum* Kalchbr. (*Porotheleum poriaeforme* [Pers. ex Fr.] W. B. Cooke).

Porotheleum poriaeforme (Pers. ex Fr.) comb. nov.

Peziza anomala γ *poriaeformis* Pers., Syn. Meth. Fung. **1**: 656. 1801
Peziza poriaeformis DC., Fl. Fr. **6**: 26. 1815
Peziza poriaeformis (Pers.) Fr., Syst. Myc. **2**: 106. 1822
Peziza tephrosia Pers., Myc. Eur. **1**: 271. 1822
Peziza pruinata Schw., Schrift. Natur.-Ges. Leipzig **1**: 120. 1822
Solenia urceolata Wallr. ex Fr., Elench. **2**: 28. 1828
Theleporus cretaceous Fr., Hornsch. Skand. Beitr. **2**: 338. 1847, sensu Rick.
Tapesia poriaeformis (DC.) Fckl., Jahrb. Nass. Ver. Nat. **23–24**: 301. 1871
Solenia poriaeformis (DC.) Fckl., Jahrb. Nass. Ver. Nat. **25–26**: 290. 1872
Solenia porioides (Alb. & Schw.) Fckl., Jahrb. Nass. Ver. Nat. **27–28**: 6. 1873
Solenia grisella Quél., Soc. Bot. Fr. Bull. **24**: 329. 1877
Stigmatolemma incanum Kalchbr., Grev. **10**: 104. 1882
Solenia porioides (Alb. & Schw.) Quél., Ench. 215. 1886
Porothelium incanum (Kalchbr.) Sacc., in Syll. Fung. **6**: 423. 1888
Tapesia pruinata (Schw.) Sacc., Syll. Fung. **8**: 379. 1889
Porothelium cinereum Pat., Soc. Myc. Fr. Bull. **9**: 130. 1893
Porothelium tenue Pat., Soc. Myc. Fr. Bull. **9**: 131. 1893
Henningsomyces poriaeformis (DC. ex Fckl.) O.K., Rev. Gen. Pl. **3**(2): 483. 1898
Henningsomyces porioides (Alb. & Schw. ex Fckl.) O.K., Rev. Gen. **3**(2): 483. 1898
Henningsomyces urceolatus (Wallr. ex Fr.) O.K., Rev. Gen. Pl. **3**(2): 483. 1898
Henningsomyces grisellus (Quél.) O.K., Rev. Gen. Pl. **3**(2): 483. 1898
Theleporus griseus Rick, Brotéria, Ser. Bot. **5**: 15. 1906
Porothelium pruinatum (Schw.) Pat., Tax. Hymén. 57. 1900
Solenia subporiaeformis Burt, Mo. Bot. Bard. Ann. **11**: 24. 1924
Solenia poriaeformis var. *urceolata* (Wallr. ex Fr.) Pilát, Ann. Mycol. **23**: 168. 1925
Cyphella grisella (Quél.) Bourd. & Galz., Hym. Fr. 163. 1927
Cyphella poriaeformis (DC) Bourd. & Galz., Hym. Fr. 163. 1927
Solenia tephrosia (Pers.) Lentz, Iowa Acad. Sci. Proc. **54**: 147. 1947

Forming incrusting, non-removable patches, variable in size and irregular in outline, which more often fuse to make much-elongated areas with rather definite margins; composed of a layer next the wood or bark made up of extremely delicate interwoven hyaline hyphae 1.5–4 μ in diameter, with clamps, in which are imbedded for about one-third to one-half of their depth the receptacles whose entire surface is covered with similar hyphae; receptacles minute, circular or somewhat flattened, about 4–5 to a mm, which nearly touch when expanded, about 90–110 μ deep and covered over the entire outside with white, granular, easily removable crystals like a powder, while the inside is covered with the smooth hymenium; under moderate power they look like citron covered with powdered sugar, and when the powder is rubbed off they are seen to be brown, strongly contrasting in surface view with the white incrusted felt in which they are seated; wall of cups about 30–40 μ thick, brown, the hymenium occupying a little less than half of this thickness and less dark than the closely woven outer part; margin incurved and partly closing the cups when dry; color of fungus in fresh condition dull white in some specimens, little darkened by the small openings of the receptacles and almost entirely due to the fine white crystals covering the subiculum hyphae and the hyphae on the cup surface; in other specimens the fructifications may be reddish-brown where the crystalline cover is weak, or blackish where the cups are very mature; cups appearing at first as minute papillae, punctate at the top, extending to within a millimeter of the margin, later formed almost up to the marginal line; basidia clavate, 4-sterigmate, 14–18 × 3.5–7 μ; spores hyaline, smooth, apiculate, globose to ovate, more or less flattened on one side, (4–)5–7.5(–8) × (1–)3.5–4(–5) μ, or when strictly globose, 3.5–6 μ in diameter; special hairs may form a palisade around margin of receptacle, 20–40 × 1–2.5 μ, straight to branched like dendrophyses.

Habitat: On bark and rotten wood, especially of: *Acer* sp., *Abies* sp., *Alnus* sp., *Amelanchier* sp., *Artemisia campestris, Betula* spp., *Castanea* sp., *Cedrus atlantica, Corylus* sp., *Fagus* sp., *Juglans cinerea, Liquidambar styraciflua, Magnolia* sp., *Picea* sp., *Pinus* sp., *Populus* sp., *Pyrus malus, Quercus* sp., *Salix* sp., *S. alba, S. lasiandra, S. triandra, Tecoma radicans, Tilia americana, Ulmus* sp., *Vitis aestivalis, V. labrusca.*

Type specimens examined:

Solenia subporiaeformis Burt: Venezuela: Margarita Island, July 11, 1903. Coll. A. F. Blakeslee. (MO 56064, FH.)

Stigmatolemma incanum Kalchbr.: Union of South Africa: Somerset, Coll. MacOwan. Comm. Karsten. (CGL 17601 in NFC.)

Solenia crustosa Coker, in herb.: North Carolina: Apr. 15, 1920. (NCU 4275, MO, FH.)

Three specimens have been studied for which no published reference has been found to the names used on the herbarium packets. These include: *Theleporus cinereus* Pat. (as *Teleporus*) fide Rick, from a specimen at the University of Michigan, *Solenia grisella* var. *theleporus* Rick, and *Porothelium griseum* Rick, at the National Fungus Collections.

Solenia porioides (Alb. & Schw.) Fckl. has large spores 7–8 ×3–4 μ, according to an authentic specimen from the Fuckel Herbarium at NFC.

A portion of the probable type of *Stigmatolemma incanum* Kalchbr., of which a specimen from Karsten is found in the Lloyd Herbarium as *Porothelium incanum*, cited above, has spores 7 × 4 μ.

Specimens examined from: Austria (9), Czechoslovakia (1), France (3), Sweden (3), Switzerland (1); Union of South Africa (3), Tunis (1), French Morocco (1); Tahiti (2); Argentina (1), Brazil (6), Ecuador (3), Venezuela (1), Canal Zone (1); Ontario (1); Alabama (1), Delaware (1), Georgia (1), Iowa (1), Louisiana (3), Maine (2), Maryland (1), Massachusetts (1), Minnesota (1), New Hampshire (4), New Jersey (3), North Carolina (8), New York (1), South Carolina (1), Virginia (1).

Specimens as above but spores regularly subglobose, 3–5 × 4–6 μ.

Specimens examined from: Austria (2), Czechoslovakia (2), Germany (3), Great Britain (1), Portugal (1), Sweden (7); Brazil (7), Colombia (1), Ecuador (3), Venezuela (1); British Columbia (1), Ontario (20), Quebec (1); Iowa (3), Louisiana (3), Maryland (3), Massachusetts (2), Missouri (2), New England (1), New Jersey (1), Ohio (1), Pennsylvania (1), Virginia (3), Wisconsin (1).

A number of collections of this fungus have been made from *Vitis* spp. in eastern Virginia and North Carolina. This material is consistently white and has globose spores. It is well described by Coker in notes accompanying material collected by Couch and sent to Burt for confirmation. This material carries the herbarium name of *Solenia crustosa*.

The specimens with globose or subglobose spores do not appear consistently enough to recognize them as belonging to a separate specific or subspecific category at present. The degree of incrustation of the subiculum and receptacle hyphae, resulting in the white to dark grey color of the whole fructification, is likewise not of specific value in this group so far as examination of the 138 specimens and their duplicates and replicates has shown.

Porotheleum huia (G. H. Cunn.) comb. nov.

Solenia huia G. H. Cunn., Roy. Soc. N. Zeal., Trans. **81**: 179. 1953

Subiculum annual, felted, white, loosely attached, effused, forming small, sharply defined, orbicular or linear areas 1–15 mm long and up to 160 μ thick; pilei aggregated in groups of a few (4–6) or many (30–80) in scattered areas, depressed-globose, sessile, 250–600 μ in diameter, opening tardily by a narrow naked pore, seated within loculi in the subiculum, each differentiated by a more densely woven zone and filled with loosely woven hyphae; exterior covered with felted white tomentum of hyaline, woven, crystal-coated hyphae which, when removed, expose the almost black glabrous wall; margin naked, even, almost black; context fuscous, to 70 μ thick, composed of densely woven, almost pseudo-parenchymatous, hyphae; generative hyphae to 3 μ in diameter, wall 0.25 μ thick, at first hyaline, becoming fuscous near the periphery, branched, septate, finely crystal-coated; hymenial layer to 40 μ deep, paraphyses subclavate; basidia subclavate, 24–32 × 6–7 μ, 4-spored; spores oblong, with rounded ends, apiculate, 7–9 × 5–6.5 μ, smooth, hyaline.

Habitat: on *Leptospermum ericoides*.

Type and specimen examined: New Zealand, 50 ft., Huia. Coll. Nov. 1945 by G. H. Cunningham. (NZPD 4392.)

The above description was taken from Cunningham (**1953**). I would add that all hyphae have clamp connections. The portion of the type specimen kindly sent by Dr. Cunningham is exactly like the description and, except for broader spores, is exactly like most of the material seen of *Porotheleum poriaeforme*.

Subgenus **Phaeoporotheleum** subgen. nov.

Sporis brunneis; subiculo pulvinato.

Spores brown, smooth to asperulate, subiculum pulvinate, annual to apparently perennial in development.

Type: *Porotheleum revivescens* Berk. & Curt.

POROTHELEUM REVIVESCENS Berk. & Curt., Jour. Linn. Soc. Lond. Bot. **10**: 324. 1869 (as *Porothelium*)

Subiculum a dense mat of tissue up to 2 mm thick, composed of hyaline to yellow, densely interwoven, smooth to incrusted, flexuous hyphae, *Poria*-like; receptacles embedded throughout the subiculum, 75–150 μ high by 100–300 μ wide, covered with brown hyphae, incrusted with yellowish granules, 25–80 × 4–5 μ, more or less flexuous; cups

when sterile becoming filled with hyphal tissue between seasons of growth; basidia 4-sterigmate, 20–22 × 6–7 μ; spores ellipsoid, apiculate, smooth, hyaline at first, becoming yellow-brown, 19.8 × 7.2 μ.

Habitat: On living trunks, on old wood and bark; on bark of *Psidium guaiava* and *Pilocarpus racemosus*.

Specimens examined from: Cuba (6), Jamaica (3), Guadeloupe (3).

First described from Louisiana. Berkeley & Curtis state that it was earlier listed as *Stereum halei* by Curtis.

POROTHELEUM BOMBYCINUM Speg., Fung. Guaran. 1, Ann. Soc. Cient. Arg. **16**: 242. 1883 (as *Porothelium*)

Receptacles embedded in a dense mat, up to 1 mm thick, of hyaline, very thick to solid-walled hyphae; hyphae branched, rarely septate; without clamps; cupules to 150 μ in diameter, hemispheric; subhymenial hyphae parallel, thin-walled, simple-septate, without clamps; basidia 16.5 × 6.5 μ, 4-sterigmate; spores at first hyaline, thin-walled, smooth, rapidly becoming dark brown, thick-walled, asperulate, spherical, 5–7.5 μ in diameter, asperulations up to 1 μ long.

Habitat: On wood of *Bambusa* sp.

Type and specimen examined: Paraguay: Carapegna, July 24, 1883. Coll. B. Balansa n. 3893. (LPS 25881.)

EXCLUDED SPECIES

POROTHELIUM FULVUM Ell. & Ev. (nom. nud.), in Langlois, Cat. Pl. Basse-La. 33. 1887. The specimen examined was a *Hypocrea*. Determined by P. L. Lentz as *Hypocrea citrina* Fr. according to E. K. Cash (**1953**).

POROTHELIUM CONFUSUM Berk. & Br., Ann. Sci. Nat., ser. V. **1**: 24. 1878. Specimens examined were *Odontia sudans*.

HENNINGSOMYCES INCANA O.K., 1898. = *Solenia fasciculata* Pers., 1822. = *S. incana* A. & S. in Pers., 1825.

ACKNOWLEDGMENTS

Acknowledgment is made of the cooperation of the members of the staffs of the Departments of Botany and of Plant Pathology, The State College of Washington, and of Dr. Paul W. Kabler, Chief of Microbiology, Robert A. Taft Sanitary Engineering Center, in encouraging the continuance of this study. The directors of the 37 herbaria to be listed in the paper on *Solenia* have kindly loaned material for study.

Various libraries have aided in bibliographic research including those of the New York Botanical Garden, The National Fungus Collections, The State College of Washington, and the Lloyd Library. Constructive criticism during the progress of this work has been given by Donald P. Rogers, C. Gardner Shaw, P. H. B. Talbot, John A. Stevenson, and many others. Assistance with Latin diagnoses has been kindly given by Miss Elizabeth C. Bridge.

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OBSERVATIONS ON GYMNOASCACEAE. V. DEVELOPMENTAL MORPHOLOGY OF TWO SPECIES REPRESENTING A NEW GENUS OF THE GYMNOASCACEAE[1]

HAROLD H. KUEHN

(WITH 30 FIGURES)

During the past several years I have obtained a number of isolates of gymnoascaceous fungi which cannot be referred properly to any of the existing genera as presently constituted. These isolates fall near *Arachniotus* and *Byssochlamys;* indeed, I once considered them to be representatives of *Byssochlamys* (Kuehn **1954**, **1957**). However, this disposition is not satisfactory, since they differ from *Byssochlamys* as well as from *Arachniotus* in important particulars. Therefore, it was felt that a new genus must be erected to include these forms.

OBSERVATIONS

Pseudoarachniotus gen. nov.

Cleistotheciis nullis; ascorum gregibus peridio carentibus, hyphis sterilibus juxta ascos orientibus peridii laxi instar efformantibus; ascis octosporis, evanidis; ascosporis hyalinis, roseis, luteis vel flavis, globosis, ovoideis, ellipticis vel lentiformibus; chlamydosporis vel oidiis exstantibus vel nullis; fructificatione conidiorum in sterigmatibus ortorum nulla.

Discrete cleistothecia lacking; peridial hyphae absent, although sterile hyphae may arise near the asci to present the appearance of a loose peridium; ascocarp initials consisting of a discrete antheridium and ascogonium; croziers present; asci 8-spored, evanescent; ascospores

[1] Grateful acknowledgment is made to Dr. C. W. Hesseltine, Northern Utilization Research Branch, USDA, Peoria, Illinois, and Lt. West and Dr. Libero Ajello, Communicable Disease Center, Atlanta, Georgia, for supplying cultures of the fungi examined. The writer also wishes to thank Dr. Leland Shanor for reading the manuscript, Dr. R. K. Benjamin for suggestions and comments over the past several years, and Dr. D. P. Rogers for his assistance in the preparation of the Latin diagnoses.

hyaline, red, or shades of yellow, globose, ovoid, elliptical or lenticular, smooth or sculptured; imperfect stage present or absent, never represented by conidia borne on sterigmata; racquet mycelium present or absent.

Type species: *Pseudoarachniotus roseus.*

Pseudoarachniotus roseus sp. nov.

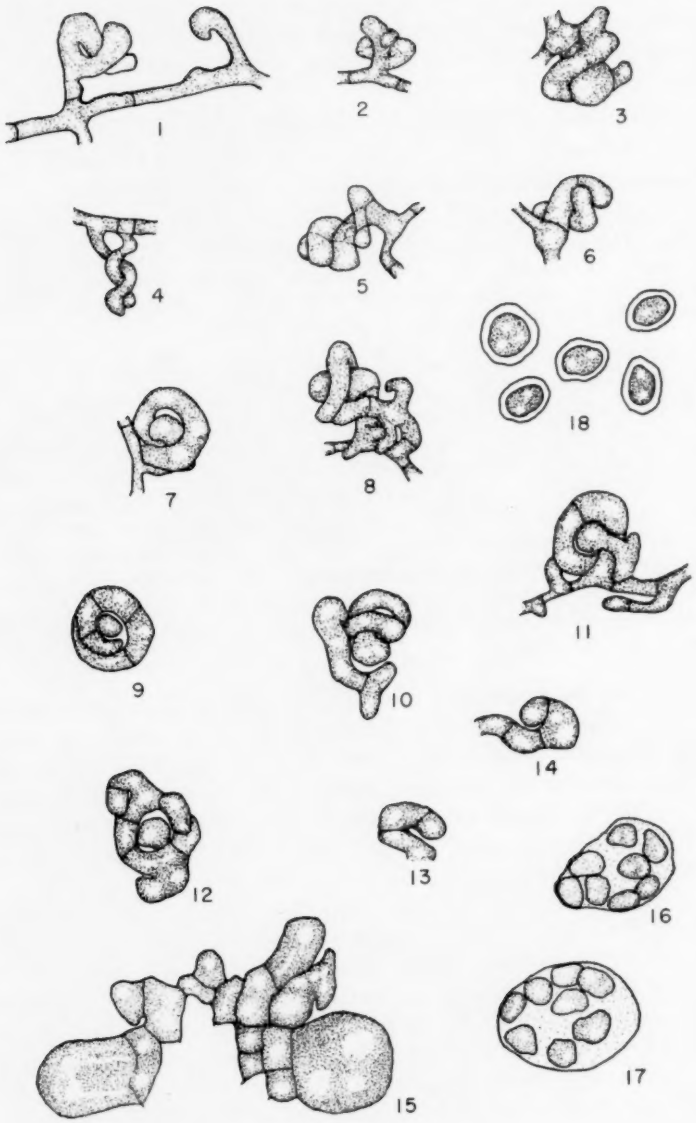
Cleistothecii nullis; ascorum gregibus 22–45 μ diam., vel in greges majores confluentibus, peridio carentibus; ascis hyalinis, ovoideis vel obovatis, evanidis, octosporis, 8.4–9.8 × 8.8–12.6 μ; ascosporis roseis, colore flavo-luteo tinctis, levibus, ovoideis vel lentiformibus, 3.6–5.6 × 4.0–7.0 μ; hyphis sterilibus hyalinis, 1.2–3.2 μ diam.; nullis chlamydosporis, oidiis vel fructificatione conidica.

Cleistothecia lacking; asci in exposed groups scattered among the vegetative hyphae; individual groups of asci measure 22–45 μ in diam., but often are merged with one another into larger masses of indefinite shape and dimensions; frequently the clusters of asci are extremely limited, consisting of as few as 4–7 asci; asci hyaline, ovoid to obovate, 8.4–9.8 × 8.8–12.6 μ; ascus wall evanescent, with the eight ascospores adhering in a group, 10.8–11.2 × 11.9–12.6 μ; ascospores red, tinged orange-yellow, ovoid to lenticular, 3.6–5.6 × 4–7 μ, frequently slightly angular, but often this character is apparent only at 1800 times magnification, otherwise smooth; vegetative hyphae hyaline, 1.2–3.2 μ in diam.; racquet mycelium encountered infrequently; no imperfect spore type known for this species.

Colonies on Sabouraud's dextrose and maltose agars grow rapidly at room temperature, at first white, turning orange within six days, remaining white at the margins, but otherwise become red-orange and turning dull maroon with age. Reverse of the colony is cream-color with a pink marginal zone. Asci appear in 4–6 days as red knots scattered among the aerial hyphae. Mature ascospores are present in six-day-old cultures.

Colonies on Czapek's agar exhibit almost no aerial growth with the exception of clusters of asci which appear on the surface of the substratum. The mycelium is very sparse and is difficult to detect.

The isolate representing this species was received from Dr. Hesseltine, labeled NRRL *1677*. It is also designated as No. *5439* in the Thom Collection. It was isolated from an ulcerated chicken gizzard in the vicinity of Tucson, Arizona. A transfer has been deposited in the culture collection of the Centraalbureau voor Schimmelcultures, Baarn, Netherlands.



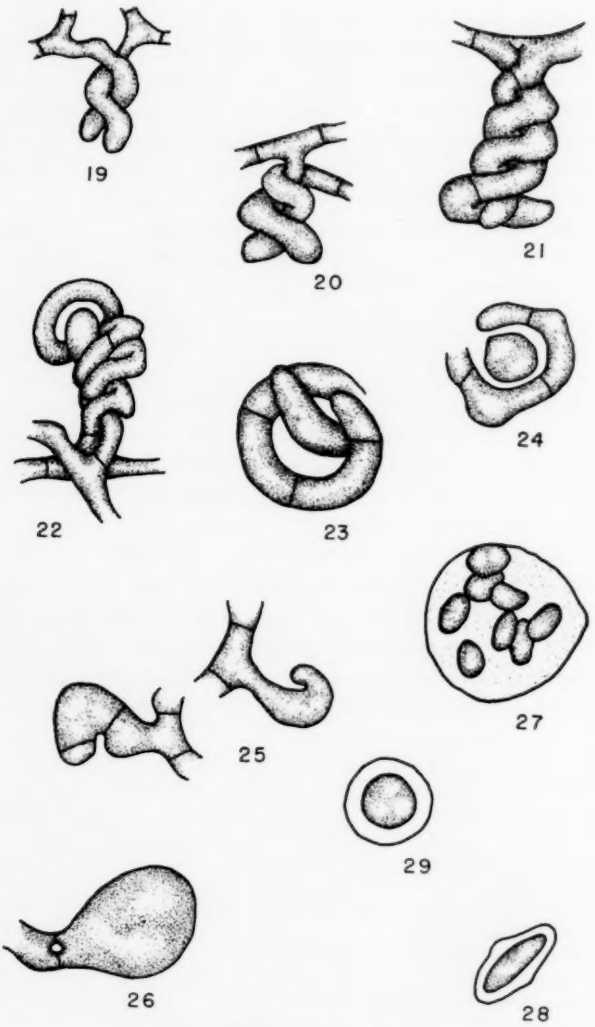
FIGS. 1–18.

The gametangial initials are quite variable in appearance. Often they arise from a common parent hypha which consists of a short lateral branch from another hypha (FIGS. 1, 3, 5). This lateral branch bifurcates into two branches which are delimited by septa and proceed to coil about one another. The two spiralling branches may be similar in appearance (FIG. 5), or the central antheridium may be straight and club-shaped with the slender ascogonium coiling about it (FIGS. 2, 3).

Several instances were noted in which the copulating branches arise close to one another on the same parent hypha (FIG. 4). Each becomes separated by a septum from the parent hypha, after which the branches begin a mutual coiling. One or two septa appear in the antheridium, which then ceases elongation. The ascogonium continues to elongate and spirals 2 or 3 times about the antheridium. A visible fusion of the gametangia was not detected. Septa are deposited which divide the ascogonium into 5 to 8 cells (FIG. 9), some of which produce short ascogenous hyphae with croziers (FIG. 12). Near the base of the coiling initials vegetative branches may appear, but these remain short and develop no further (FIG. 8).

The penultimate cells of the croziers form asci immediately by enlarging (FIG. 15). No instances were observed in which the penultimate cell elongated to form another crozier, nor did the cell resulting from fusion of the antepenultimate and ultimate cells grow out into a lateral crozier. The result is a very small and compact group of asci which lies completely exposed among the vegetative hyphae.

FIGS. 1–18. *Pseudoarachniotus roseus*. 1. Origin of gametangia. A short lateral branch of a hypha bifurcates to produce an antheridium and an ascogonium. 2. The ascogonium begins to coil about the antheridium. 3. Both gametangia are delimited by septa. A branch is initiated from the base of the ascogonium. 4. Gametangia are produced as adjacent branches on the same parent hypha. 5–6. Once-septate ascogonia. 7. A coil as seen from above, with the ascogonium completing one spiral about the antheridium. 8. Septate gametangia, with vegetative branches appearing near the base of each. 9. A coil seen from above, with the septate ascogonium about the central antheridium. 10. A loose coil, with the apex of the ascogonium free from the antheridium although the apical cell of the ascogonium has already developed an ascogenous hypha. 11. Older coil with a septate ascogonium and with vegetative branches arising on the parent hypha below the gametangia. 12. A coil seen from above with recurved ascogenous hyphae. 13–14. Stages in crozier development. 15. A portion of a group of immature asci formed from one pair of gametangia. This shows the limited size of the group of asci, and also depicts stages in crozier development to form asci. 16–17. Mature asci. 18. Mature ascospores. All figures × 1300.



FIGS. 19–29.

FIGS. 19–29. *Pseudoarachniotus citrinus.* 19–20. Initial stages in coiling of the gametangia, with the two initials arising from different parent hyphae. 21. Initials arising from the same parent hypha, with each gametangium once-septate. 22. An older coil of several-septate gametangia. 23. Coil as seen from above.

Pseudoarachniotus citrinus (Massee & Salmon) comb. nov.
Arachniotus citrinus Massee & Salmon, Ann. Bot. **16**: 62. 1902.

Discrete cleistothecia absent. Clusters of asci completely exposed, scattered among the vegetative hyphae. Individual groups of asci vary greatly in size and often merge with one another to form very large masses of asci. Asci ovoid, hyaline, 8.8–9.3 × 10.8–12.8 μ, 8-spored, wall evanescent. Ascospores smooth, lemon-yellow, subglobose or elliptical. Spores subglobose, 4.8–5.1 μ in diam., or elliptical, measuring 3.1–4.4 × 5.3–6 μ and slightly compressed. Wall of the elliptical ascospores thickened terminally and also in a median band around the spore. Vegetative hyphae lemon-yellow, 1.2–3.3 μ in diam. No racquet mycelium has been found, nor is an imperfect spore type known for this species.

Colonies on Yp.Ss. agar (Emerson, **1941**) at room temperature are white at first, but become light-yellow, then lemon-yellow, and finally, in older portions, olive-yellow. The hyphae in the peripheral zone of the colony remain white. Reverse of the colony is cream-color initially, but later it assumes various shades of brown. There is a zone at the margin between the lemon-yellow and the olive-yellow areas where many droplets of a colorless exudate are formed. Older portions of the colony become furrowed. Mature asci can be found within 7 days. The individual groups of asci at first are white, and therefore are easily distinguished, but they are difficult to detect later for the yellow ascospores blend with the yellow vegetative hyphae.

The gametangia arise from the same parent hypha (FIG. 21) or from different hyphae (FIGS. 19, 20). They are similar in appearance and begin a mutual coiling immediately upon contact with one another. After coiling about each other 2 or 3 times, each gametangium becomes divided into several cells. Ascogenous hyphae arise as outgrowths from several cells of the ascogonium. No fusion of the two gametangia could be detected; on the contrary, FIG. 24 illustrates ascogenous hyphae being initiated from an ascogonium which at that stage had not fused with the antheridium. The ascogenous hyphae remain short and soon form croziers (FIG. 25). However, these initial croziers do not produce asci but form additional ascogenous hyphae and croziers in the manner which has been described by the author for other species of

24. Coil from above, with ascogenous hyphae beginning to arise from the septate ascogonium. 25. Ascogenous hyphae which have recurved to form croziers. 26. A young ascus. 27. Ascus with immature ascospores. 28. Mature elliptical ascospore. 29. Mature subglobose ascospore. All figures × 1300.

Gymnoascaceae. Eventually, penultimate cells of croziers enlarge to form asci. In this manner, a rather large group of asci may be formed from each pair of gametangia. No vegetative hyphae arise from the base of the coil, nor do any of the surrounding vegetative hyphae become differentiated to form a peridium, with the result that the asci lie free in the hyphal tangle.

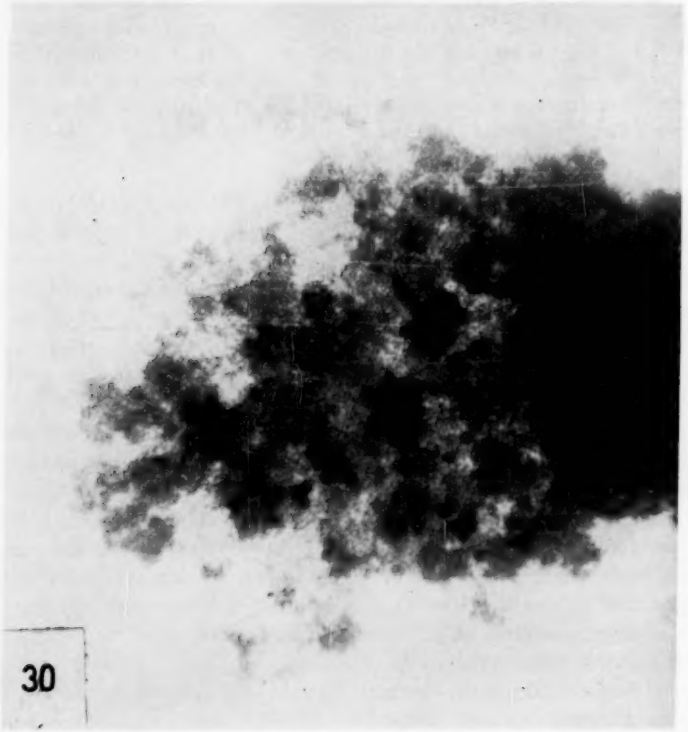


FIG. 30. Ascospore clusters in *Pseudoarachniotus roseus* showing the individual groups of asci scattered among the vegetative hyphae, × 175.

This isolate was received from Dr. Libero Ajello and Lt. Billy West, Communicable Disease Center, Atlanta, Georgia, who had isolated it from Tennessee soils and identified it as *Arachniotus citrinus* (**1956**). There is little doubt that this isolate represents the same species as that which Massee and Salmon (**1902**) described as *Arachniotus citrinus,* and the differences in ascospore dimensions may be attributed to strain

variation. However, there is absolutely no trace of a peridium, a fact which also was noted by West and Ajello. Therefore, this species cannot be retained in *Arachniotus* as constituted by Schroeter (**1893**), as the ensuing discussion will show. Since West and Ajello presented photomicrographs which illustrate the complete absence of peridial hyphae, no additional illustrations seem to be required here.

ARACHNIOTUS CANDIDUS (Eidam) Schroeter, Cohn's Krypt.-Fl. Schles. **3**(*2*): 210. 1893.

Gymnoascus candidus Eidam, Ber. Bot. Sect. Schles. Ges. **1886**: 161. 1886.

Several cultures labeled *Arachniotus candidus* were received from the Centraalbureau voor Schimmelcultures. Unfortunately, none has ever produced asci on any of the media upon which they were cultured. Herbarium specimens of Gymnoascaceae from the New York Botanical Garden were made available through the courtesy of Dr. D. P. Rogers, curator. Material of *Arachniotus candidus* was examined in an effort to establish the nature of the ascocarp. However, the material was of such age that it was impossible to determine what the original relationship was between the ascus clusters and the vegetative hyphae. Therefore, we must rely on the literature in an evaluation of this species since the type is not available. Such an evaluation is presented in the discussion section of this paper.

It is desirable to present here a description of *Arachniotus candidus* as compiled from the literature.

Fruiting bodies snow-white, globose, 0.5–2 mm diam., often confluent; peridial hyphae (reported absent by Dale, **1903**) irregularly branched, scanty, thin-walled, smooth and delicate; asci small, oval (Schroeter, **1893**, Eidam, **1886**), globose (Massee and Salmon, **1902**), 8-spored, evanescent, 5–6 μ diam.; ascospores hyaline, ellipsoid, smooth, 3–3.5 μ (Eidam, Schroeter), 3–3.5 × 2.5 μ (Massee and Salmon). Old clusters of asci appear slightly yellow-white (Eidam), but Massee and Salmon state the species remains persistently snow-white throughout its development. Imperfect stage absent (Eidam), consisting of oidia (Dale), or of pyriform conidia in chains with sterile intercalary segments (Schroeter). It is probable that Schroeter saw chlamydospores.

My observations on the non-fruiting strain obtained from C.B.S. are as follows.

Colonies on Sabouraud's maltose agar are slow-growing, attain a diameter of 3 cm in 20 days, at first are bacteria-like, mucoid, but soon

white aerial hyphae arise. Older colonies possess a white, restricted, flocculent central portion with the margins bacteria-mucoid-like. Reverse colorless, the color is that of the agar.

DISCUSSION

Schroeter (**1893**) based the genus *Arachniotus* on three species previously described as *Gymnoascus aureus* Eidam (**1886**), *G. candidus* Eidam (**1886**) and *G. ruber* Van Tieghem (**1877**). According to Schroeter this new genus was characterized by a peridium composed of thin-walled, uniform hyphae interwoven to form a web-like membrane. *Arachniotus candidus* (Eidam) Schroeter is the type for the genus. Dale (**1903**) obtained the type material from Eidam for her study of the species, and in her report she stated that the asci are without any type of investment. In other words, a peridium is absent. A critical examination of the original description by Eidam (**1886**) reveals an interesting and pertinent statement. Eidam reported that the peridium was formed long after the ascospores had attained maturity. Furthermore, this peridium was formed from hyphae which covered the ascospores, leaving no interstices. Evidently this process of peridium formation took place as the cultures aged and dried and the vegetative hyphae collapsed about the clusters of ascospores. The structures which Eidam regarded as ascocarps in all probability were merely the groups of ascospores which persisted as the aerial mycelium collapsed about them to form discrete structures.

DeLamater (**1937**) reported his observations on a species which resembled *Arachniotus aureus* (Eidam) Schroeter, although not quite identical with it. He stated that the asci were merely nestled at random among the aerial hyphae with no other special protective sterile cells about them that might correspond to a peridium.

Arachniotus trisporus Hotson was accepted as an *Arachniotus* species by the workers at the Centraalbureau, and they recognized it to be the same species which Vailionis (**1936**) had described that same year as *Gymnoascus sudans*. Neither Hotson (**1936**) nor Rosenbaum (**1944**) mentioned the complete lack of a peridium in *A. trisporus*. However, other workers, Cain (**1956**) and R. K. Benjamin (**1956**), as well as the author (**1954, 1957**), realized that a peridium was absent and that the species belongs in the genus *Byssochlamys*. The placement of this species in three different genera by different workers typifies the confusion with respect to one simple character—the nature of the peridium. It also illustrates the need for a re-alignment of species and a re-statement of generic limitations.

Type material for *A. candidus, A. ruber* and *A. aureus* has not been located to date. However, Eidam (**1886**) presented a discussion and comparison of these three species. In his opinion *A. aureus* had a peridium which was very loose and full of gaps. *Arachniotus ruber* was characterized by producing very few asci per cluster, from 6 to 20, from each pair of initials. Each gametangial coil formed an extremely loose peridium which was composed of a few hyphae which enclosed the asci in a manner resembling a lattice. Eidam contrasts these with *A. candidus,* which he represents as having a rather firm peridium almost like a membrane. It is apparent that Eidam considered the vegetative hyphae which developed by chance near the asci as constituting a peridium. If Dale considered *A. candidus* to lack a peridium completely, by comparison *A. aureus* and *A. ruber* must indeed be devoid of such a structure. This type of "peridial" relation occurs not only in species of *Pseudoarachniotus* but also in *Byssochlamys fulva* and to a greater extent in *B. nivea.*

If we exclude a peridium for the three original species it might seem that *Arachniotus* is a genus based on false criteria. However, at least two species are known which fit Schroeter's concept of the genus; these are *Arachniotus* sp. RSABG 202, as illustrated by R. K. Benjamin (**1956**), and *Arachniotus reticulatus* Kuehn (**1957**). It is possible that a reinvestigation of all the previously described species of *Arachniotus* which are available will reveal some which illustrate the characteristics of the genus as Schroeter described it. Moreover, a diligent search should be made for type specimens of the three original species of the genus, and great effort should be made to reisolate new strains of these species from nature. Until such a time, placement of these species and an evaluation of the genus must be postponed. It is hoped that the arguments presented in this paper will lead to renewed efforts, especially on the part of investigators in Europe, in this respect.

Among those species now included in *Arachniotus* and *Pseudoarachniotus* which are available at the present time there are none which produce conidia on penicillate structures. Only two such species have been described, *A. ruber* (Van Tieghem) Schroter and *A. trachyspermus* Shear (**1902**). R. K. Benjamin (**1956**) stated that these species must be reisolated before it will be possible to determine whether they are to be retained in the Gymnoascaceae or transferred to the Eurotiaceae. However, we can probably eliminate *A. ruber* from consideration as possessing such an asexual stage since Eidam (**1886**) reported no asexual stage and stated that Van Tieghem must have worked with impure cultures. It is very likely that *A. trachyspermus* actually be-

longs in the *Talaromyces* series (C. R. Benjamin **1955**) and may possibly be a strain of *Talaromyces* (*Penicillium*) *spiculisporus*. I have isolated several fungi which initially appeared to be Gymnoascaceae, but which upon further study were determined to be representatives of the *Penicillium luteum* (Raper and Thom **1949**), or *Talaromyces* (C. R. Benjamin **1955**) series. That an identical situation could be present with respect to *A. trachyspermus* is indicated by the descriptions of this species given by Hotson (**1936**), Rosenbaum (**1944**) and Shear (**1902**), especially in view of two facts: first, the habitat of *A. trachyspermus*, diseased cranberries, is an unlikely one for Gymnoascaceae but very likely for Penicillia; second, with two exceptions, *Byssochlamys nivea* Westling (**1909**) and *B. fulva* Olliver & Smith (**1933**), no other Gymnoascaceae have penicillate asexual stages. *Gymnoascus flavus* Klöcker (**1902**) has been interpreted to have such a stage, but Klöcker specifically states that the conidia, while borne in chains, are always subterranean in the medium. He illustrates the conidia borne on simple branches, not in penicillia. These "conidia" are in all probability chlamydospores, and are considered as such by me.

The separation of species now included in *Pseudoarachniotus* from those now included in *Arachniotus* can be made on the basis of the presence or absence of a peridium. In neither genus does there occur one indisputable instance of the production of conidia on penicillia. The only species in the family which are definitely known to possess penicillate structures are those of *Byssochlamys*. R. K. Benjamin (**1956**) stated that it is not yet apparent what taxonomic significance is to be placed on the imperfect stages of the Gymnoascaceae. However, in a more recent personal communication he indicated that the imperfect stages might be a very important indicator of relationship and are as much a genetic character as the features of the perfect stage. Therefore, by erecting the non-penicillate *Pseudoarachniotus* as distinct from the penicillate *Byssochlamys* we place the latter genus closer to, if not within, the Eurotiaceae and emphasize the difference in imperfect stages between the Gymnoascaceae (chlamydosporic and oidial) and the Eurotiaceae (conidial-penicillate). Such generic distinctions will permit a clearly defined separation of all the species encountered, and will enable the investigator to assign these species with assurance to the genera involved in this complex: *Talaromyces, Byssochlamys, Pseudoarachniotus* and *Arachniotus*.

C. R. Benjamin (**1955**) stated that the genus *Talaromyces* is composed of a series of forms which constitute a transition from the lower Gymnoascaceae to the Eurotiaceae, but while it often was difficult to

separate *Arachniotus* species from those of *Talaromyces* in his opinion the two genera should remain distinct. The writer concurs with this viewpoint. It is felt that species of *Talaromyces* form a natural group and should be kept distinct from *Arachniotus*. These genera seem to intergrade on the basis of ascocarp morphology. However, *Arachniotus* and *Pseudoarachniotus* are distinctly different from *Talaromyces* with respect to the imperfect stage. Moreover, information available at this time indicates that croziers are formed in all species of *Arachniotus* and *Pseudoarachniotus* while they usually are absent in *Talaromyces*. The two species of *Byssochlamys* not only have penicillate imperfect stages but also develop croziers. Thus, the close relation of *Byssochlamys* to *Talaromyces* is evident. By creation of the genus *Pseudoarachniotus* and by placing more emphasis upon the imperfect stages, we clearly separate the *Arachniotus* line from the *Talaromyces* line. According to this scheme *Pseudoarachniotus* would be the evolutionary precursor of *Arachniotus* while *Byssochlamys* would occupy the same position with respect to *Talaromyces*. Although the author originally considered *Byssochlamys* as a representative of the Gymnoascaceae (**1955**) it now seems more likely that *Byssochlamys* should be placed with *Talaromyces* in the Eurotiaceae.

SUMMARY

Two species, *Pseudoarachniotus roseus* and *P. citrinus*, are described as representatives of a new genus of Gymnoascaceae. One of these species, *P. roseus*, is described as new. The morphological development and other diagnostic characteristics are presented for *P. roseus* and *P. citrinus*. In both species the gametangia consist of coiling initials which may be designated as antheridia and ascogonia. From the ascogonium there arise ascogenous hyphae which form asci following production of croziers. The groups of asci which arise are entirely devoid of peridial hyphae. This characteristic lack of a peridium, plus the presence of discrete antheridia and ascogonia, the formation of croziers, and the lack of conidia on phialides, distinguish the new genus, *Pseudoarachniotus*. The interrelationships of *Byssochlamys, Talaromyces, Pseudoarachniotus* and *Arachniotus* are discussed.

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THE AGARIC FLORA OF TEXAS. I. NEW SPECIES OF AGARICS AND BOLETES [1, 2]

HARRY D. THIERS

An investigation of the agaric flora of Texas has been in progress since 1951. Although collecting has been confined so far to the pine-oak belt in the eastern part of the state, a number of new and interesting species have been discovered. A general analysis of the flora of this region was given in an earlier report (**2**). The present paper is the first of a series containing descriptions of some of the undescribed taxa found in the area. The field work has been carried on chiefly in the fall and spring, since during these periods the climatic conditions are most conducive to carpophore formation. The severe drought conditions existing in this area have precluded other than sporadic collecting for the past three years.

The type collections have been deposited in the herbarium of the University of Michigan, Ann Arbor, Michigan.

Boletus roseibrunneus sp. nov.

Pileus 4.5–7 cm latus, late convexus vel plano-convexus, "pecan brown" [3] vel "walnut brown" demum "burnt umber" vel "Vandyke brown," siccus, glaber; caro "pale greenish yellow" vel "light greenish yellow"; sapor ingratus; tubuli adnexi, secedentes, "light greenish yellow" vel "greenish yellow" demum "oil yellow"; stipes 4–6 cm longus, 0.6–1.1 cm crassus, "light greenish yellow," maculatus "chestnut" vel "burnt sienna," siccus, glaber; sporae fusoideae vel subellipsoideae, 11–14 × 4–7 μ; cystidia subfusoidea vel cylindrica vel filamentosa, 40–64 × 4–9 μ.

Pileus 4.5–7 cm broad, broadly convex when young, remaining broadly convex or becoming plano-convex when fully expanded, margin incurved when young, becoming straight or slightly incurved with age,

[1] Portion of a dissertation submitted to the Faculty of the University of Michigan in partial fulfillment of the requirements of the degree of Doctor of Philosophy.

[2] The author wishes to express his sincere appreciation to Dr. A. H. Smith for his continued assistance and guidance throughout the study. Grateful acknowledgment is also made to my wife, Ellen Thiers, for preparation of the Latin diagnoses.

[3] All colors given in quotations are from Ridgway, Color Standards and Nomenclature. Washington, D. C. 1912.

entire, surface dry, glabrous, dusty rose to brown ("pecan brown" to "walnut brown") when young, chocolate brown ("burnt umber" to "Vandyke brown") with age.

Flesh thick (±1 cm), pale greenish yellow ("pale greenish yellow" to "light greenish yellow") when young, not changing with age, unchanging upon exposure, taste unpleasant, odor not distinctive.

Tubes adnexed, seceding with age, greenish yellow ("light greenish yellow" to "greenish yellow") when young, becoming olive yellow ("oil yellow") with age, unchanging upon bruising, mouths 0.5–1 mm in diam., not stuffed.

Stipe 4–6 cm long, 0.6–1.1 cm broad at the apex, equal except for slight flaring at the base, stuffed, surface dry, glabrous, occasionally possessing obscure reticulations near the apex, greenish yellow ("light greenish yellow") but marked with splotches of red to orange-red ("chestnut" to "burnt sienna").

Spores pale brown in KOH, fusoid to subcylindric or subellipsoid in face view, inequilateral in side view, smooth, thin-walled, 11–14 × 4–4.7 μ; basidia narrowly clavate, 2- and 4-spored, 31–39 × 6–8 μ; cystidia scattered, subfusoid to cylindric to nearly filamentous, hyaline, thin-walled, 40–64 × 4–9 μ; tube trama obscurely divergent to subparallel, composed of hyaline, filamentous hyphae ±6 μ in diam.; pileus trama interwoven, composed of hyaline, filamentous hyphae ±12 μ in diam.; cuticle differentiated as a layer of interwoven, filamentous hyphae ±6 μ in diam., staining brown in KOH; examined for clamp connections but none found.

Gregarious in sandy humus in mixed pines and hardwoods in a mixed forest near Navasota, Grimes Co., Texas. September 29, 1951. H. D. Thiers 1402 (TYPE).

This species appears to be closely related to *Boletus hypoxanthus*, but that species has a mild taste, granulose-velvety pileus, paler and more yellow-brown pileus and punctate-granular stipe. *Xerocomus pseudoboletinus*, the only other bolete with which it is likely to be confused, is characterized by larger spores, a punctate stipe and a tomentose covering on the pileus.

Boletus silvaticus sp. nov.

Pileus 6.5–9.5 cm latus, convexus vel plano-convexus, "raw umber" demum "raw sienna" vel "amber brown" vel "antique brown," siccus, glaber vel pruinosus; caro alba; sapor amarus; tubuli conferti, breviter decurrentes vel depressi, "light buff" demum "ochraceous buff" vel "ochraceous tawny," tactu "amber yellow" vel "yellow ocher"; stipes 3–6 cm longus, 1–2 cm crassus, "sayal brown" vel "snuff brown" demum "clay color," siccus, glaber, reticulatus ad apicem; sporae ellipsoideae vel cylindricae, 11–18.6 × 3–3.7 μ; cystidia fusoidea vel subclavata, 18–31 × 9–11 μ.

Pileus 6.5–9.5 cm broad; convex to broadly convex when young, remaining broadly convex or becoming plano-convex when older, margin incurved when young, becoming broadly decurved to spreading with age, entire, surface dry, dull, glabrous to pruinose, dark brown ("raw umber") when young, fading to dull orange ("raw sienna" to "amber brown" or "antique brown") when mature.

Flesh thick (1–2 cm), white, unchanging upon exposure, taste bitter, odor not distinctive.

Tubes very crowded, flush with the cap margin, slightly decurrent to depressed at the stipe, cream colored ("light buff") when young, becoming pale tan ("ochraceous buff") and finally changing to light brown or occasionally olivaceous ("ochraceous tawny" to "orange citrine") with age, changing to dull yellow ("antimony yellow" to "yellow ocher") upon bruising, mouths small (0.4–0.8 mm), angular, not stuffed.

Stipe 3–6 cm long, 1–2 cm broad at the apex, equal, stuffed, light brown to brown ("sayal brown" to "snuff brown") when young, fading to clay ("clay color") when older, surface dry, glabrous except for reticulations at the apex (noticeable at least when dried).

Spores light brown in KOH, smooth, thin-walled, narrowly ellipsoid to cylindric, 11–18.6 × 3–3.7 μ; basidia narrowly clavate to subcylindric, 4-spored, 18–23 × 7–11 μ; cystidia numerous, filled with amorphous material which stains orange-yellow in KOH, highly vacuolate, thin-walled, fusoid to subclavate, apices obtuse to subacute, 18–31 × 9–11 μ; tube trama composed of large ($\pm 8\ \mu$), hyaline, filamentous hyphae which are divergent to obscurely parallel; pileus trama interwoven, composed of large ($\pm 9\ \mu$), hyaline, filamentous hyphae; cuticle strongly differentiated as a turf of closely packed, thin-walled pilocystidia which are vesiculose to globose with an elongated, acute to subacute apex, staining pale yellow in KOH, 62–69 × 15–26 μ; examined for clamp connections but none found.

Gregarious in sandy humus under pines and hardwoods in mixed forest near Navasota, Grimes Co., Texas. September 29, 1951. H. D. Thiers 1403 (TYPE).

This fungus is probably closely related to *Boletus affinis* as shown by the similarly colored pilei which are glabrous to pruinose, the white flesh, and the similar cystidia. The cuticle is a well differentiated turf of pilocystidia, whereas that of *Boletus affinis* is composed of more or less upright hyphal tips which do not form a true turf. It also differs from *Boletus affinis* by having larger spores which are somewhat darker colored in KOH, a bitter taste, tubes that are buff to ochraceous in color and a brown rather than pallid stipe. The dark colored pileus distinguishes it from *Xanthoconium stramineum*.

Lactarius mordax sp. nov.

Pileus 6–12.5 cm latus, subdepressus demum infundibuliformis, "light buff" vel "warm buff" demum "cream color" vel "cinnamon buff," siccus, glaber, azonatus; caro alba; lac album, copiosum; sapor acer; lamellae subdecurrentes, confertae, albae, demum "pale ochraceous buff" vel "pale pinkish buff"; stipes 3–6 cm longus, 2–3 cm crassus, albus demum "cream color" vel "cinnamon buff," siccus, glaber; sporae minute verrucosae, late ellipsoidae vel subglobosae, 9–10.9 × 6.2–8 μ.

Pileus 6–12.5 cm broad, shallowly depressed, remaining so or becoming deeply depressed to infundibuliform, margin appearing somewhat matted-tomentose when young, becoming glabrous at maturity, strongly inrolled when young, becoming broadly decurved to plane with age, entire, surface dull, dry, glabrous, occasionally becoming rimose to areolate-scaly with age, azonate, when young, yellow to tan ("light buff" to "cartridge buff" to "warm buff"), when older becoming ivory to tan ("ochraceous buff" to "cream color") with irregularly distributed light brown ("clay color") spots.

Flesh thick (2–2.5 cm), white, unchanging upon exposure, latex white, abundant, unchanging when exposed, staining the flesh lavender to pale brown, taste very acrid, odor not distinctive or occasionally pungent, unpleasant, near spermatic.

Lamellae short-decurrent, close to crowded, forking occurring near the base and part way to the margin, white when young, becoming tan ("pale ochraceous buff" to "pale pinkish buff") with age, staining yellowish ("warm buff") at first changing to lavender ("light vinaceous drab") and finally yellow-brown ("buckthorn brown") when dry, margin entire, concolorous with the gill faces; lamellulae irregularly distributed.

Stipe 3–6 cm long, 2–3 cm broad at the apex, equal to tapering downward, sometimes bulbous at the base, stuffed, becoming hollow, white when young, becoming ivory ("cream color" to "Massicot yellow") to tan ("cinnamon buff") with age, occasionally staining yellow upon bruising, surface dry, glabrous except for occasional whitish bloom on young forms.

Spores hyaline in KOH, strongly amyloid, finely verrucose, not reticulate, ellipsoid to subglobose, 9–10.9 × 6.2–8 μ, apiculus eccentric, 1–1.5 μ long, warts 0.5 μ or less high; basidia clavate to subcylindric, 4-spored, 47–54 × 9–11 μ, sterigmata long (±7 μ); pleurocystidia numerous to abundant, embedded in the hymenium except for the apex, cylindric to aciculate to fusoid with subacute to mucronate apex, hyaline, thin-walled, 38–54 × 4–7 μ; cheilocystidia abundant, similar to the pleurocystidia except projecting farther from the hymenium and slightly smaller; gill trama composed of nests of sphaerocysts surrounded by hyaline, filamentous hyphae ±6 μ in diam. with interspersed lactifers; pileus trama composed of narrow (±3 μ), loosely interwoven, non-

gelatinous, filamentous hyphae surrounding nests of sphaerocysts; cuticle differentiated as a layer (50–100 μ broad) of narrow ($\pm 3\ \mu$), loosely interwoven, non-gelatinizing, filamentous hyphae sometimes staining ochraceous in KOH; examined for clamp connections but none found.

Solitary to gregarious in humus under oaks and loblolly pines. Mixed woods near Navasota, Grimes Co., Texas. May 22, 1952. H. D. Thiers 1570 (TYPE). Open oak woods near clay pits, Wellborn, Brazos Co., Texas, in May. No. 1832.

The dry, glabrous, buff colored pileus, acrid taste, more or less glabrous stipe and interwoven, filamentous cuticle make it difficult to place this fungus in its proper taxon. The odor varies from non distinctive to very strong and unpleasant. The viscid pileus and apparent absence of any staining discoloration of the flesh makes *Lactarius affinis* distinct from this species. The filamentous, interwoven cuticle makes it distinct from any of those having a turf of pilocystidia forming the cuticle. The tendency of the pileus to become areolate or rimose with age suggests *Lactarius rimosellus* but it has a mild latex, smaller spores, and the base of the stipe is more or less strigose. *Lactarius piperatus* is distinct because of its white pileus, very crowded lamellae and no apparent discoloration of the flesh when exposed.

Lactarius albolutescens sp. nov.

Pileus 3–5.6 cm latus, convexus demum subdepressus, "ochraceous buff" vel "cinnamon buff," udus vel subviscidus; caro "pale pinkish buff," lac album, aeri expositum luteum; lamellae subdecurrentes, confertae, "light grayish vinaceous" vel "light russet vinaceous"; stipes 1.8–2.5 cm longus, 8–10 mm crassus, glaber, siccus, "ochraceous buff"; sporae verrucoso-reticulatae, ellipsoideae vel ovoideae, 7.8–9.3 × 6–6.5 μ.

Pileus 3.5–6 cm broad, convex to nearly plano-convex becoming shallowly depressed with broadly decurved margin, margin not incurved or inrolled when young, entire, surface moist to slightly viscid, soon dry, glabrous, azonate, tan to light brown ("ochraceous buff" to "cinnamon buff" or "pinkish cinnamon") through all stages of development, disc sometimes darker red ("vinaceous tawny"), drying dark yellow.

Flesh thick (1–1.5 cm) near the disc, becoming very thin toward the margin, pale tan ("pale pinkish buff"), unchanging upon exposure, latex white at first but changing to greenish yellow ("Martius yellow") within 15–20 seconds after exposure, finally drying light brown or tan, taste mild to very weakly acrid, odor not distinctive.

Lamellae subdecurrent, narrow, close, lavender ("light grayish vinaceous" to "light russet vinaceous"), unchanging upon bruising, margin entire; lamellulae of 2–3 lengths.

Stipe 1.8–2.5 cm long, 8–10 mm broad at the apex, equal to tapering slightly toward the base, solid, surface glabrous, dry, dark tan ("ochraceous buff"), unchanging when bruised.

Spores hyaline in KOH, strongly amyloid, verrucose-roughened, forming a broken reticulum, broadly ellipsoid to ovoid, apiculus eccentric, 7.8–9.3 × 6–6.5 μ, warts 0.5–1.3 μ high, connecting lines ±0.5 μ high; basidia clavate, 4-spored, 31–39 × 7–9 μ; pleurocystidia scattered to numerous, deeply embedded in the hymenium, thin-walled, filled with amorphous substance, fusoid to nearly cylindrical, 41–54 × 7–9 μ; cheilocystidia similar to the pleurocystidia; gill trama without sphaerocysts, composed of a central compact strand with filamentous hyphae ±6 μ in diam. and lactifers ±8 μ in diam.; cuticle differentiated as a very broad band (±220 μ) of appressed, filamentous, narrow (±3 μ) hyphae which slowly gelatinize in KOH, surmounting a hypoderm (±20 μ) of compactly interwoven hyphae; examined for clamp connections but none found.

Gregarious to scattered in humus in mixed pine-hardwood forest. Sam Houston National Forest near Richards, Montgomery Co., Texas. December 31, 1951. H. D. Thiers 1426 (TYPE).

The characters which distinguish this fungus are the white latex that turns yellow when exposed and dries brown, the smooth, viscid, glabrous pileus, the weakly acrid taste, the absence of any noticeable odor and, perhaps most important, the lavender lamellae. It has some resemblance to members of the "scrobiculatus" group but the glabrous pileus and the absence of any spots on the stipe separate it from either *Lactarius scrobiculatus* or *Lactarius cilicioides*. The lack of any strong odor, and the pale buff, azonate pileus distinguishes it from *Lactarius theiogalus* as well as from *Lactarius chrysorheus* and *Lactarius croceus*. The complete absence of any striations on the pileus makes it distinct from *Lactarius isabellinus*, and the relatively large carpophores and other characters distinguish it from *Lactarius xanthydrorheus*. *Lactarius controversus* is distinguished by having a latex that does not change color, a white stipe and smaller spores.

Lactarius albus sp. nov.

Pileus 3.5–5 cm latus, planus demum subdepressus, albus, tactu "ochraceous buff" vel "antimony yellow," udus vel siccus, tomentosulus, azonatus; caro alba; lac album, copiosum; sapor acer; lamellae confertae, angustae, adnatae vel breviter decurrentes, "light buff," tactu "deep colonial buff"; stipes 2–4 cm longus, 7–13 mm crassus, albus, tactu "deep colonial buff" vel "olive ocher," siccus, glaber, aequalis; sporae minute punctatae, ellipsoideae vel subglobosae, 6.2–7.8 × 5.3–6.3 μ; pleurocystidia fusoidea vel subfusoidea, 42–60 × 8–10 μ, vel flexuosa, 30–45 × 5–7 μ; cheilocystidia pleurocystidis fusoideis similia.

Pileus 3.5–5 cm broad, plane, becoming plano-convex to plane with a shallow to moderately broad depression, margin strongly incurved to inrolled when young, becoming plane when mature, entire, surface moist to dry, usually with considerable debris attached, dull, appearing glabrous but minutely tomentose to velvety under a lens, azonate, white with pink, yellow or brown ("ochraceous buff" to "antimony yellow" to rarely "ochraceous tawny") stains when dried.

Flesh white, unchanging upon exposure, thick (± 1 cm), compact, latex white, abundant, unchanging, taste quickly and extremely acrid, odor not distinctive.

Lamellae crowded, very narrow, adnate to short-decurrent, occasional forking midway and at the base, tan ("light buff"), when dried brown ("ochraceous tawny" to "amber brown" to "sudan brown"), stained deep yellow ("deep colonial buff") by the latex, margin entire, concolorous with the gill faces; lamellulae not present.

Stipe 2–4 cm long, 7–13 mm broad at the apex, equal to tapering toward the base, stuffed, white, staining yellow to gold ("deep colonial buff" to "olive ocher") upon bruising, surface dry, glabrous even.

Spores hyaline in KOH, strongly amyloid, finely punctate-roughened, ellipsoid to subglobose, apiculus slightly eccentric, 6.2–7.8 × 5.3–6.3 μ, warts small, less than 0.5 μ high; basidia clavate, 4-spored, 31–40 × 9–11 μ; pleurocystidia of two types: one type scattered to numerous, fusoid to subfusoid, hyaline to pale yellow in KOH, filled with an amorphous substance, thin-walled, more common toward the gill edge, 42–60 × 8–10 μ, second type scattered, hyaline, thin-walled, filamentous, flexuous, frequently contorted, 30–45 × 5–7 μ; cheilocystidia abundant, similar to the fusoid pleurocystidia except projecting farther from the hymenium; gill trama composed of scattered sphaerocysts surrounded by connective hyphae ±4 μ in diam. and interspersed lactifers ±6 μ in diam.; pileus trama composed of small nests of sphaerocysts surrounded by connective hyphae ±4 μ in diam. and scattered lactifiers ±15 μ in diam.; cuticle differentiated as a layer ±75 μ broad, of narrow (±4 μ), hyaline, loosely interwoven to projecting hyphae, not forming a true turf, surmounting a hypoderm of closely packed, inflated cells which stain pale brown in KOH; examined for clamp connections but none found.

Gregarious to subcespitose in humus under hardwoods in mixed pine-hardwood forest. Sam Houston National Forest near Huntsville, Walker Co., Texas. June 9, 1952. H. D. Thiers 1699 (TYPE).

The white, velvety-tomentose pileus, narrow, crowded lamellae and the strongly acrid taste indicate a close relationship between this *Lactarius* and *Lactarius piperatus*. My material, however, is distinct because of the small size of the carpophore, the buff stains on the lamellae when bruised, the white stipe and the ellipsoid to subglobose spores.

Lactarius vellereus or *Lactarius subvellereus* can be readily distinguished by the narrow, crowded lamellae of the former, and from the latter by the small size of the fruiting body and the absence of green stains when bruised.

Lactarius cystidiosus sp. nov.

Pileus 4–6.5 cm latus, convexus demum subdepressus, "ochraceous buff" demum "light ochraceous salmon" vel "ochraceous salmon," siccus, pruinosus, glaber; caro alba, tactu "avellaneous"; lac album; sapor mitis; odor aromaticus; lamellae adnatae vel breviter decurrentes, confertae vel subdistantes, "ochraceous buff" demum "light buff" vel "warm buff"; stipes 2–5 cm longus, 2–2.8 cm crassus, aequalis, "light ochraceous buff" demum "warm buff," siccus, pruinosus; sporae minute verrucosae, reticulatae, ellipsoideae vel ovoideae, 8.3–9.3 × 6.2–7.8 μ; pleurocystidia clavata, 46–57 × 9–11 μ; cheilocystidia pleurocystidiis similia; pilocystidia et caulocystidia praesentia.

Pileus 4–6.5 cm broad, convex to broadly convex becoming plane with a shallow depression at the disc, margin glabrous, inrolled when young, becoming plane to decurved with age, entire, surface dry, dull, pruinose, yellowish ("ochraceous buff") when young, changing to pinkish tan ("light ochraceous salmon" to "ochraceous salmon") with age, azonate.

Flesh white, compact, thick (1–1.5 cm), changing to light brownish purple ("avellaneous") upon exposure, latex copious, white, unchanging upon exposure, taste mild to slightly bitter, odor aromatic.

Lamellae adnate, becoming short-decurrent with age, close to subdistant, broad, when young yellowish ("ochraceous buff") changing to paler buff ("warm buff" to "light buff") with age, unchanging when bruised, margin entire, concolorous with the gill faces; lamellulae alternating with the lamellae.

Stipe 2–5 cm long, 2–2.8 cm broad at the apex, equal, solid, yellowish ("light ochraceous buff") when young, becoming more ochraceous ("warm buff") when older, unchanging when bruised, surface dry, dull, pruinose.

Spores hyaline in KOH, strongly amyloid, finely verrucose, reticulate, ellipsoid to ovoid, 8.3–9.3 × 6.2–7.8 μ, warts 0.6–1 μ high, connecting lines less than 0.5 μ high; basidia hyaline, clavate, 4-spored, 46–54 × 9–11 μ; pleurocystidia scattered, deeply embedded in the hymenium, hyaline, thin-walled, frequently having mucilaginous accretions at the apex, clavate, basidioid, 46–57 × 9–11 μ; cheilocystidia similar to the pleurocystidia; gill trama composed of numerous hyaline, thin-walled, sphaerocysts with scattered connective hyphae $\pm 4\ \mu$ in diam. and occasional lactifers $\pm 8\ \mu$ in diam.; pileus trama consisting of numerous nests of sphaerocysts surrounded by large ($\pm 9\ \mu$), hyaline lactifers and narrow ($\pm 4\ \mu$), connective hyphae; cuticle differentiated as a turf of

narrow ($\pm 4\,\mu$), hyaline, thin-walled hyphae tips (pilocystidia) surmounting a compact layer of globose, thin-walled cells which stain pale brown in KOH; surface of the stipe covered with a turf of caulocystidia similar to those on the surface of the pileus; examined for clamp connections but none found.

Gregarious in humus in a mixed pine-hardwood forest. Sam Houston National Forest near Stubblefield Lake, San Jacinto Co., Texas. June 8, 1952. H. D. Thiers 1670 (TYPE).

The similarity of the cuticle, general appearance and the presence of caulocystidia indicate that this *Lactarius* is very closely related to the *Lactarius volemus–Lactarius hygrophoroides* complex. *Lactarius cystidiosus* is distinct from *Lactarius volemus* in that the latter has thick-walled metallic cystidia and more nearly ellipsoid than globose spores. The close to subdistant lamellae, the pale color of the pileus when fresh and the presence of pleurocystidia are characters which separate it from *Lactarius hygrophoroides.*

Lactarius eburneus sp. nov.

Pileus 4.5–6.5 cm latus, depressus vel subinfundibuliformis, "cartridge buff" vel "cinnamon buff," siccus, tomentosulus, azonatus; caro albida; lac album, parvum; sapor mitis; lamellae confertae vel subdistantes, adnatae vel subdecurrentes, "light buff" vel "warm buff," tactu "ochraceous salmon" dein "light ochraceous buff" vel "warm buff"; stipes 3–4.5 cm longus, 8–15 mm crassus, albus, tactu "buckthorn brown" vel "ochraceous tawny," siccus, glaber; sporae verrucoso-reticulatae, ovoideae vel subglobosae, 7.8–9.3 × 6.2–7.8 μ; pleurocystidia cylindrica vel clavata apice subacuta vel mucronata, 40–62 × 6–11 μ; cheilocystidia filamentosa vel flexuosa, 34–68 × 6–8 μ.

Pileus 4.5–6.5 cm broad, plane with a shallow depression to shallowly infundibuliform, margin incurved, becoming plane to slightly decurved, entire, surface dry, more or less even, minutely tomentose under the lens, dull, azonate, yellow ("cartridge buff" to "ivory yellow") to tan ("cinnamon buff") during all stages of development.

Flesh thick (± 1.5 cm), white, unchanging upon exposure, latex scant, white, unchanging, taste mild, odor not distinctive.

Lamellae close to subdistant, moderately broad, adnate to slightly decurrent, forking rare, occurring near the base, yellowish ("light buff"), staining at first pink ("ochraceous salmon" to "light ochraceous buff") then to tan ("light buff") when bruised, margin entire, concolorous with the gill faces; lamellulae of 2–3 lengths.

Stipe 3–4.5 cm long, 8–15 mm broad at the apex, equal, stuffed, white, staining brown ("buckthorn brown" to "ochraceous tawny"), surface dry, glabrous.

Spores pale buff in KOH, strongly amyloid, strongly verrucose, forming a heavy reticulum, broadly ovoid to subglobose, 7.8–9.3 × 6.2–7.8 μ, warts 1–3 μ high, coarse, heavy connecting lines 0.5–1.5 μ high; basidia clavate, apparently 2- and 4-spored, 31–40 × 11–14 μ; pleurocystidia abundant, filled with hyaline, amorphous material, thin-walled, cylindric to clavate with subacute to mucronate apices, embedded in the hymenium, 40–62 × 6–11 μ; cheilocystidia abundant, hyaline, thin-walled, filamentous to flexuous with elongated, obtuse apices, 36–48 × 6–8 μ; gill trama composed of numerous conspicuous lactifers ±5 μ in diam. containing hyaline, amorphous material and connective hyphae with sphaerocysts rare or absent; pileus trama consisting of numerous lactifers ±10 μ in diam. and connective hyphae ±6 μ in diam. surrounding occasional nests of sphaerocysts; cuticle differentiated as a layer of very compactly interwoven, filamentous hyphae staining pale brown in KOH surmounting a loosely interwoven, sub-gelatinous, hyaline hypoderm; examined for clamp connections but none found.

Scattered in humus under oaks and other hardwoods in mixed pine-hardwood forest. Sam Houston National Forest near Huntsville, Walker Co., Texas. June 10, 1952. H. D. Thiers 1701 (TYPE).

The minutely tomentose, dull yellowish pileus and the mild, white, unchanging latex place this fungus in the Lactifluae of Burlingham. In this group *Lactarius subvelutinus* seems to be the nearest relative. My material may be distinguished by the buff rather than golden pileus, the pink discoloration of the lamellae, the strongly verrucose spores that are definitely not white, and the brown stains on the stipe. It can be distinguished from *Lactarius luteolus* by the salmon stains on the lamellae and the buff spores.

Lactarius echinatus sp. nov.

Pileus 3.5–7.5 cm latus, convexus demum plano-convexus vel depressus, "ivory yellow" interdum "deep olive buff," siccus, subtomentosus vel pruinosus; caro alba; lac album, immutabile vel "avellaneous"; sapor acer; lamellae adnatae, confertae vel subdistantes, "light buff" demum "pale ochraceous buff," tactu "warm sepia" vel "verona brown"; stipes 2–2.5 cm longus, 1.4–1.7 cm crassus, albus vel concolorous, siccus, pruinosus vel subtomentosus; sporae minute echinulatae, late ellipsoideae vel subovoideae, 7.8–9 × 5.5–6.5 μ; pilocystidia et caulocystidia praesentia.

Pileus 3.5–7.5 cm broad, obtusely convex becoming plane to plano-convex with a shallow depression, margin strongly incurved to inrolled when young, becoming nearly plane to decurved with age, entire, surface dry, subtomentose to pruinose, dull, light yellow ("ivory yellow") when young, changing to pale olivaceous ("deep olive buff") or unchanging with age.

Flesh white, thick (±1 cm), compact, changing to brownish lavender ("avellaneous") when exposed, latex white, abundant, sometimes slowly changing to brownish lavender ("avellaneous"), taste acrid, disagreeable, odor not distinctive.

Lamellae adnate, close to subdistant, narrow, forking occurring near the base, yellowish ("light buff") when young, unchanging or becoming pale tan ("pale ochraceous buff") with age, staining dark brown ("warm sepia" to "verona brown") upon bruising, margin entire, concolorous with the gill faces; lamellulae of 1–2 lengths.

Stipe 2–2.5 cm long, 1.4–1.7 cm broad at the apex, equal to tapering slightly toward the base, stuffed, white to nearly concolorous with the pileus, surface dry, pruinose to subtomentose, dull.

Spores hyaline in KOH, strongly amyloid, thin-walled, finely echinulate, not reticulate, broadly ellipsoid to subovoid, apiculus slightly eccentric, 7.8–9 × 5.5–6.5 μ, warts 0.5–1 μ high; basidia clavate, 2- and 4-spored, hyaline, 40–46 × 8–9 μ; pleurocystidia of two types: one type abundant, deeply embedded in the hymenium, thin-walled, filled with an amorphous substance staining brown in KOH, cylindric to subclavate with subacute to obtuse apices, 37–47 × 7–9 μ; second type hyaline, scattered to rare, thin-walled, aciculate to subfusoid, 31–39 × 3–4 μ; cheilocystidia abundant, extending for a short distance along the sides of the lamellae, thin-walled, nearly filamentous to flexuous, usually capitate with a short neck, 36–62 × 6–9 μ; gill trama composed of scattered sphaerocysts with surrounding connective hyphae ±3 μ in diam. and broad (±8 μ), hyaline lactifers; pileus trama composed of hyaline nests of sphaerocysts surrounded by narrow (±4 μ) connective hyphae and large (±8 μ), hyaline lactifers; cuticle differentiated as a broad turf (±100 μ) of narrow (±4 μ), hyaline, filamentous to flexuous, nongelatinizing pilocystidia; caulocystidia forming a turf on the surface of the stipe similar to that of the cuticle; examined for clamp connections but none found.

Scattered in humus under hardwoods in mixed pine-hardwood forest. Sam Houston National Forest near Huntsville, Walker Co., Texas. June 10, 1952. H. D. Thiers 1700 (TYPE).

The combination of characters shown by this fungus makes it difficult to assign it to any established taxon. The general appearance of the carpophores suggests relationship to the Lactifluae of Burlingham. Members of that group, however, do not have an acrid taste and develop brown rather than avellaneous stains when bruised. More specifically, this fungus looks like an acrid *Lactarius volemus*, but, in addition to the difference in staining reactions, the spores of *Lactarius volemus* are heavily verrucose-reticulate whereas in *Lactarius echinatus* they are echinulate. When compared with any of the species characterized by

avellaneous or lavender stains *Lactarius echinatus* shows only superficial similarities.

Lactarius obnubiloides sp. nov.

Pileus 2–3 cm latus, planus vel plano-convexus, "russet" vel "Mars brown" demum "light ochraceous salmon" vel "tawny," siccus, glaber; caro fragilis, "pale ochraceous buff"; lac album; sapor mitis; lamellae breviter decurrentes, confertae vel subdistantes, "light pinkish cinnamon"; stipes 2–3 cm longus, 5.5–7.5 mm crassus, "vinaceous fawn" vel "fawn," siccus, glaber; sporae late ellipsoideae vel subglobosae, verrucosae, reticulatae, 6.2–7.8 × 6.2–7.2 μ; cellulae cuticulae clavatae vel ellipsoidae, hyalinae.

Pileus 2–3 cm broad, plane to plano-convex during all stages of development, frequently with a short, subacute umbo, margin slightly incurved when young, unchanging or becoming plane with age, entire, surface dry, dull, glabrous, not striate, dark brown ("russet" to "Mars brown") when young, fading to pinkish tan to brown ("light ochraceous salmon" to "tawny") with age.

Flesh thin (±0.5 cm), brittle, ivory ("pale ochraceous buff"), unchanging upon exposure, latex white, unchanging when exposed, taste mild, odor spicy.

Lamellae short decurrent, close to subdistant, narrow, pale tan ("light pinkish cinnamon") when young, unchanging or becoming dull pink ("light vinaceous cinnamon") with age, margin entire, concolorous with the gill faces; lamellulae of 2–3 lengths.

Stipe 2–3 cm long, 5.5–7.5 mm broad at the apex, equal to tapering downward, usually somewhat flattened at the apex, solid to stuffed, pale purple to purple brown ("vinaceous fawn" to "fawn") during all stages of development, surface dry, glabrous.

Spores hyaline in KOH, strongly amyloid, broadly ellipsoid to subglobose, verrucose-roughened, reticulate, apiculus long (1.5–2 μ), eccentric, 6.2–7.8 × 6.2–7.2 μ, warts 1–3 μ high, connecting lines 0.5–1 μ high; basidia clavate, 2- and 4-spored, 31–39 × 7–9 μ; pleurocystidia scattered to numerous, deeply embedded in the hymenium, hyaline, nearly cylindric to narrowly fusoid, with slightly elongated, mucronate apices, 23–31 × 6–8 μ; cheilocystidia numerous, similar to the pleurocystidia; gill trama composed of closely interwoven, narrow (±4 μ), filamentous hyphae, sphaerocysts not observed; pileus trama composed of discrete nests of sphaerocysts surrounded by connective hyphae ±6 μ in diam. and scattered lactifers; cuticle differentiated as a turf of enlarged, hyaline, thin-walled, ellipsoid cells; examined for clamp connections but none found.

Gregarious to subcespitose in humus under oaks and other hardwoods. Hardwood forest near Millican, Brazos Co., Texas. May 22, 1952. H. D. Thiers 1595 (TYPE).

The similarity of the type of cuticle found on this fungus and that of *Lactarius obnubilus* as well as the similarity in size and general appearance of the carpophores indicates that the two are closely related. The Texas collection has been compared with material collected by Smith in Michigan and the microscopic characters are very similar. The major differences were found in spore size, with *Lactarius obnubilus* having larger spores, and the projecting pleurocystidia. Macroscopically *Lactarius obnubilus* has much thinner flesh, a broader stipe, a striate margin and a viscid pileus. These are all characters not found in *Lactarius obnubiloides*.

Amanita alba sp. nov.

Pileus 3.5–7.5 cm latus, obtuse convexus vel plano-convexus, albus, squamulosus vel granulosus; caro alba; lamellae albae, liberae, confertae vel subdistantes; stipes 8–12.5 cm longus, 1–2 cm crassus, albus, valde granulosus vel squamosus, aequalis, basi leviter bulbosus; annulus albus, sursum glaber, deorsum tomentosus; volva evanida vel squamosa; sporae hyalinae, amyloideae, globoseae vel subglobosae, 7.8–10 × 7.8–8.7 μ; pleurocystidia et cheilocystidia nulla.

Pileus 3.5–7.5 cm broad, obtusely convex, becoming broadly convex to nearly plane, margin strongly incurved and attached to the stipe when young, becoming decurved when mature, entire, surface dry to moist, covered with large, very soft, somewhat angular squamules which are composed of white fibrils that often become aggregated into recurved scales with age, sometimes granular and friable, white during all stages of development.

Flesh thick (0.5–1 cm), white, unchanging, taste oily-bitter, odor not distinctive.

Lamellae free, close to subdistant, broad, white, unchanging with age or upon bruising, margin entire, concolorous with the gill faces; lamellulae of 2–3 lengths.

Stipe 8–12.5 cm long, 1–2 cm broad at the apex, equal, a slight bulb at the base, stuffed to hollow, surface densely granulose-squamulose, shaggy, squamules soft, easily removed, white; annulus superior, white, glabrous above, cottony-tomentose below, flaring, membranous, attached; volva usually evanescent, present as a series of irregular rows of easily detached, fibrillose warts along the base of the stipe.

Spores hyaline in KOH, amyloid, thin-walled, smooth, apiculus slightly eccentric, globose to subglobose, 7.8–10 × 7.8–8.7 μ; basidia clavate, 4-spored, 33–38 × 6–9 μ; pleurocystidia and cheilocystidia absent; gill trama obscurely divergent, hyphae filamentous, hyaline, ± 3 μ in diam.; pileus trama composed of interwoven, hyaline hyphae 5–8 μ in diam.; cuticle composed of loosely attached, chains of hyaline, ellipsoid cells; examined for clamp connections but none found.

Gregarious on lawn of Mrs. A. A. Blumberg, College Station, Brazos Co., Texas. September 11, 1952. H. D. Thiers 1713 (TYPE).

This fungus is characterized by amyloid, globose to subglobose spores and an obscure volva. The pure white pileus and coarse, squamulose surface distinguish it from *Amanita citrina* and *Amanita porphyria*. My material would seem to be close to *Amanita aestivalis* and *Amanita abrupta*, but the former has a glabrous pileus, and the latter has a large, abrupt bulb that is either glabrous or somewhat ridged or cracked. It is readily distinguished from *Amanita virosa* and *Amanita phalloides* by not having a bulb with a free-margined volva.

Amanita salmonea sp. nov.

Pileus 6–8 cm latus, convexus vel planus, siccus, levis, glaber demum fibrillosus vel squamosus, "salmon buff" demum "cinnamon rufus" vel "hazel" vel "seashell pink"; caro alba; lamellae liberae, albae, latae, confertae vel subdistantes; stipes 6–8 cm longus, 1–1.4 cm crassus, sursum albus, glaber, deorsum "salmon buff," fibrillosus, aequalis, basi leviter bulbosus; annulus albus, crassus, sursum glaber, deorsum fibrillosus; volva squamoso-diffracta; sporae hyalinae, amyloideae, ellipsoideae vel ovoideae, 11–12.5 × 7.8–9.3 μ; cheilocystidia et pleurocystidia nulla.

Pileus 6–8 cm broad, convex, becoming broadly convex to plane, margin strongly incurved at first, becoming plane to decurved with age, appendiculate with white partial veil elements, surface dry, at first smooth and glabrous but soon breaking up into appressed to slightly recurved scales or squamules, becoming fibrillose between the scales, when young pink ("salmon buff"), when older the scales becoming dark pink ("cinnamon rufous" to "hazel") and the areas between the scales pink ("seashell pink").

Flesh thick (5–6 mm) toward the disc becoming thinner toward the margin, white, unchanging, taste and odor not distinctive.

Lamellae free, broad (6–7 mm), close to subdistant, white, margin entire, becoming eroded with age, concolorous with the gill faces; lamellulae of one length.

Stipe 6–8 cm long, 1–1.4 cm broad at the apex, equal except for a slight enlargement at the base, surface dry, covered with ferruginous ("cinnamon rufous" to "hazel"), loosely attached, appressed scales when young, when older fading to pink ("seashell pink") or unchanging or becoming almost white, white above the annulus; annulus persistent, white, moderately thick, superior, attached, margin fibrillose, glabrous above, villous to tomentose below; volva poorly developed, usually apparent only as a series of concentric rows of scales near the base.

Spores hyaline in KOH, amyloid, moderately thick-walled, apiculus eccentric, smooth, ellipsoid to ovoid to occasionally nearly globose,

11–12 × 7.8–9.3 μ; basidia elongate-clavate, 4-spored, 49–57 × 9–11 μ; pleurocystidia and cheilocystidia not differentiated; gill trama obscurely divergent, hyaline, composed of filamentous hyphae ±10 μ in diam.; cuticle poorly differentiated as a layer of closely appressed, filamentous hyphae ±4 μ in diam., staining pale yellow in KOH; examined for clamp connections but none found.

Scattered to gregarious on lawn, A. & M. College Campus, College Station, Brazos Co., Texas. September 14, 1951. H. D. Thiers 1393 (TYPE).

This *Amanita* appears to unique in the genus. So far as could be determined no other species has a cuticle that breaks up into scales as this one does. The more or less salmon pink pileus also appears highly distinctive.

Cystoderma texensis sp. nov.

Pileus 3–6 cm latus, convexus demum planus, albus demum centro "warm buff" vel "pale ochraceous buff," siccus, fibrillosus; caro alba; lamellae albae, adnatae vel adnexae, secedentes, confertae vel subdistantes; stipes 2–3 cm longus, 4–6 mm crassus, albus, siccus, sursum glaber, deorsum fibrillosus; annulus albidus, fibrillosus; sporae haud amyloideae, ellipsoideae vel ovoideae, 4.7–6.2 × 2.7–3.5 μ; pleurocystidia nulla; cheilocystidia fusoideo-ventricosa, capitata, 35–45 × 4–6 μ; cellulae cuticulae ellipsoideae vel globosae, in KOH hyalinae.

Pileus 3–6 cm broad, convex, becoming broadly convex to plane, margin incurved when young, becoming slightly incurved to plane with age, usually appendiculate from partial veil elements, surface dry, covered with numerous small scales that are somewhat appressed and scattered on the margin but becoming acute and more numerous toward the disc, white, unchanging on the margin but becoming pale buff ("warm buff" to "pale ochraceous buff") toward the disc when older.

Flesh thick (5–7 mm), white, becoming thinner toward the margin, taste and odor not distinctive.

Lamellae white, adnate to adnexed but soon seceding from the stipe, narrow, thin, close to subdistant, margin entire, concolorous with the gill faces; lamellulae of 2–3 lengths.

Stipe 2–3 cm long, 4–6 mm broad at the apex, equal except for an enlarged bulbous base, hollow, surface dry, glabrous above the annulus, scaly to fibrillose-scaly below, white during all stages of development; annulus whitish, loosely interwoven, fibrillose, attached, sometimes disappearing with age.

Spores white in mass, hyaline in KOH, non-amyloid, smooth, thin-walled, ellipsoid to narrowly ovoid, 4.7–6.2 × 2.7–3.5 μ; basidia clavate, 4-spored, 15–23 × 5–9 μ; pleurocystidia not differentiated; cheilocystidia abundant, thin-walled, hyaline, narrowly fusoid-ventricose with elon-

gated apices having a spear-shaped tip, 35–45 × 4–6 μ; gill trama interwoven to subparallel, composed of hyaline, filamentous hyphae ±6 μ in diam.; pileus trama composed of hyaline, interwoven, filamentous hyphae ±6 μ in diam.; cuticle differentiated as a layer of globose to ellipsoid, loosely attached, thin-walled cells, 15–32 × 10–18 μ, which remain hyaline in KOH, surmounting a broad (±230 μ) layer of loosely interwoven, hyaline, filamentous hyphae ±5 μ in diam.; examined for clamp connections but none found.

Gregarious in humus under pines and oaks in mixed woods. Sam Houston National Forest near Richards, Montgomery Co., Texas. December 3, 1951. H. D. Thiers 1419 (TYPE).

This species is distinct because of the absence of any staining reaction in KOH, no pleurocystidia, and relatively large, non-amyloid spores. It is similar to the white or pallid form of *Cystoderma granulosum* macroscopically; however, upon microscopic examination it can easily be separated from either *Cystoderma granulosum* or *Cystoderma cinnabarium* by the absence of any staining or discoloration of the cuticle in KOH. The spores are also somewhat larger than in either of the above species. It would have to be arranged next to *Cystoderma ambrosii* in Smith and Singer's (1) classification; however, the presence of cheilocystidia in *Cystoderma texensis* makes the two distinct.

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NOTES ON THE CHOANEPHORACEAE

C. W. Hesseltine and C. R. Benjamin

(with 9 figures)

Since the publication of the senior author's paper (**3**) on the Choanephoraceae, two significant papers have appeared on the taxonomy of this family. In one paper Poitras (**5**) reported that the conidia of *Choanephora cucurbitarum* (Berk. & Rav.) Thaxter are actually 1-spored sporangiola. Furthermore, he found that *C. conjuncta* Couch has striate sporangiospores and he therefore made it a synonym of *C. cucurbitarum*. He also reported that striations can be found on the zygospores of both *Blakeslea trispora* Thaxter and *C. cucurbitarum*. Since it had been shown that sporangiola are found in both of these species, Poitras accepted Sinha's (**7**) combination *Choanephora trispora* which was based on *Blakeslea trispora*. Thus the genus *Blakeslea* is reduced to a synonym of the genus *Choanephora*. In the second paper Naganishi and Kawakami (**4**) described a new species in the family as *Blakeslea circinans*. This species had been found but once, in pasture soil at Nanatsukahata, Hiroshima Prefecture, Japan. It produced sporangia but no sporangiola or conidia. The columellae were shown to be distinctly pyriform and the sporangiospores were longitudinally striate with clusters of radiating appendages at the ends of the spores.

The purpose of this paper is to report on our studies on *B. circinans* and to present additional notes on other species of the genus *Choanephora*. The media used are the same as those used in the studies on the Mucorales previously published from this laboratory.

OBSERVATIONS

In June, 1955, a culture was received from the Quartermaster Corps Collection as QM 565 isolated from a textile sample from the Canal Zone and identified as *Choanephora* sp. Upon examination, this strain seemed to represent a new species of *Choanephora* and was assigned NRRL 2491, but it later proved to be *Blakeslea circinans* when compared with a culture of the type strain obtained from the Institute for Fermentation, Osaka, Japan. Since matings of the above two strains did not result in any zygospore production, nothing further was done

with the species until additional strains were isolated from two soil samples collected in Trinidad by Dr. R. W. Jackson, Head of our Fermentation Section. When a considerable quantity of either of the two soil samples was placed directly upon potato-dextrose agar (PDA) in Petri dishes, many colonies of this species appeared. Zygospores were seen, and attempts were immediately made to isolate both plus and minus strains. Numerous isolates were selected and from these, two strains proved to be of opposite mating types. These were designated NRRL 2546 and NRRL 2548. When NRRL 2546 was mated with NRRL 2545 (Naganishi's original culture), zygospores were produced in abundance on PDA at 25° C.

In view of the findings of Poitras in *Blakeslea trispora* and of our own with *B. circinans*, we are transferring *B. circinans* to the genus *Choanephora*.

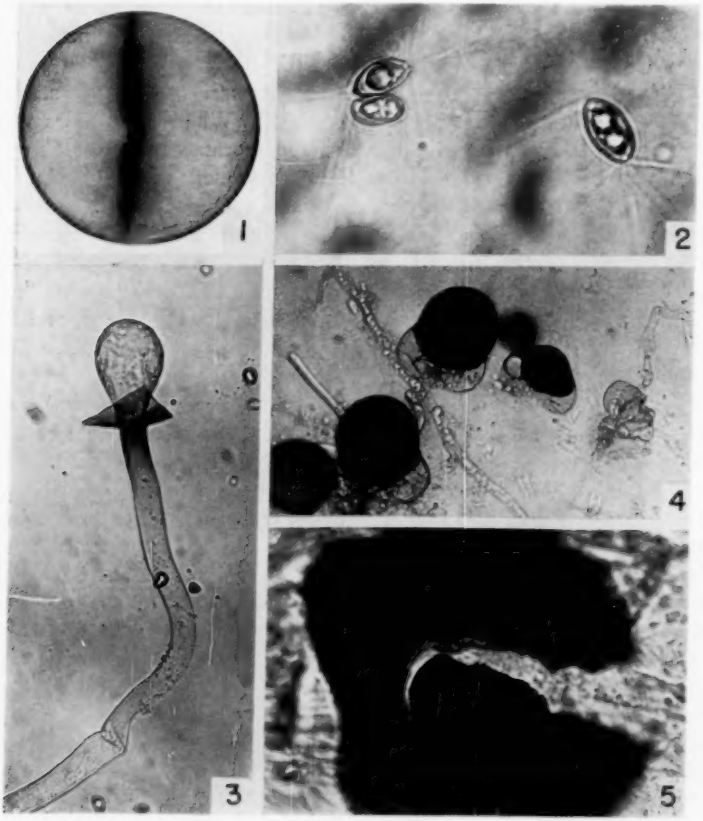
Choanephora circinans (Naganishi & Kawakami) comb. nov.

Blakeslea circinans Naganishi & Kawakami, Bull. Fac. Eng. Hiroshima Univ. **4**: 183. Figs. 1–9. 1955.

Colonies on synthetic mucor agar (SMA) for 11 days at 25° C less than 4 mm in height, growing restrictedly, with very irregular margin, at first white then Pale Olive-Buff to Cartridge Buff (**6**); colony reverse in yellow shades, near Cream-Buff; odor yeasty; aerial portion of colony made up of lax and tangled mycelia; amount of sporulation variable but never good; conidiophores or sporangiophores bearing sporangiola absent; sporangiophores arising from substrate and aerial mycelium, mostly non-septate, smooth-walled, hyaline below, gradually becoming purplish or purplish-brown above, especially just below the sporangium, bearing sporangia in a circinate or nodding fashion, never branched, up to 20 μ in diam., quite variable in length, up to 1.6 mm; sporangia at first white then yellowish and finally brownish-black, globose, breaking, 80–140 μ in diam.; sporangial wall purplish in color, splitting into two or three pieces at maturity, with surface smooth or appearing granular; columellae (FIG. 3) smooth-walled, faintly brown in color, with collar flared out as a distinct and broad ring, oval to pyriform, always longer than broad and the larger ones always pyriform, 31–67 $\times$ 36–104 μ in size; sporangiospores (FIG. 2) very irregular in shape, roughly oval, with striations visible at high magnifications, smooth-walled, hyaline, with 6 or more stiff appendages from either end up to 16.5 μ in length; sporangiospores 4.5–7.5 $\times$ 7–13.5 μ with exceptionally large spores to 8 $\times$ 18 μ, with contents sometimes vacuolate; chlamydospores intercalary, hyaline, larger than hyphae, with granular contents, usually solitary, oval in shape, 10–15 $\times$ 17–26 μ; zygospores (FIG. 4) formed at or below the surface of the medium, dark reddish-brown to

almost black, with large central oil droplet, oval to globose, 40–90 μ in diam.; zygospore wall nearly smooth, fragile and hence readily breaking, clearly striate at high magnifications; suspensors tong-shaped, arising from twisted and distorted hyphae, nearly equal in size, smooth-walled, containing yellow oil droplets or appearing empty, 20–36 μ in diam. at the largest portion next the zygospore.

Type culture: *Blakslea circinans* NRRL 2545.



FIGS. 1–5. *Choanephora circinans.* 1. Strong mating reaction between strains NRRL 2547 and NRRL 2548. 2. Sporangiospores, showing appendages. 3. Sporangiophore and columella. 4. Zygospores. 5. Portion of zygospore wall, showing striations.

Besides the Quartermaster Corps strain from textiles from the Canal Zone and the soil isolate from Japan, twenty-five isolates were secured from the two Trinidad soil samples.

The above description is based upon NRRL 2546, a Trinidad isolate, and NRRL 2545 the type culture from Japan. Studies of these isolates on SMA are the basis for the above description except that zygospores were studied on PDA. Cultures when grown on steep agar, malt agar, yeast extract agar, and PDA spread over the agar rapidly and produce abundant aerial mycelia. However, asexual sporulation is almost completely lacking. On Czapek's solution agar growth is thin and colorless, but usually a few sporangia are formed.

The presence of other fungi, such as *Alternaria*, apparently stimulates the formation of sporangia upon PDA. When this species was grown with a second fungus on PDA, the sporangiospores of *C. circinans* were 3.5–5.5 × 5.5–12 μ in size and regularly oval to elliptical in shape. The shape and size of its sporangiospores appear to be much more regular and probably are more nearly normal when *C. circinans* is grown with the second fungus.

This species can be recognized by the lack of sporangiola or "conidia," by the peculiar pyriform columella with a large collar, and by the fact that it sporulates poorly in pure culture on most media. The purplish or reddish-colored sporangial wall is quite distinctive. In spite of the absence of "conidia" or sporangiola, the presence of zygospores and the striate sporangiospores with stiff bristle-like appendages clearly makes it a member of *Choanephora* rather than *Mucor*.

Among all the species described in the family only one species besides *C. circinans* has been found which completely lacks sporangiola or "conidia." This is *C. persicaria* Eddy (**2**). Examination of an herbarium specimen made from a culture of Eddy's material proved to be *Absidia*. However, Eddy's description and illustrations indicate that he was dealing with a species of *Choanephora*. On the basis of a comparison of the published description of *C. persicaria* which had sporangiospores that were stated to be 19–22 × 11–15 μ in size, this species could not be *C. circinans*. *C. circinans* has spores which do not in their upper extremes reach the size of the smallest spores reported by Eddy. However, in many other respects the species show similarities.

The observations on zygospore formation were made upon NRRL 2545 and its reaction with various other isolates on PDA (FIG. 1). When opposite mating types are mated at 25–26° C, zygospore formation begins to appear in 24 to 48 hours as a yellow zone at the region of contact of the two colonies. Fully mature zygospores may be seen in

a week or less. The region with mature zygospores appears as a black zone across the Petri dish. In some very intense reactions a very faint purple pigment may be seen in the medium below the zygospores, as noted in matings of NRRL 2545 × NRRL 2547.

The zygospores of *C. circinans* are always formed in the medium or at its surface. A hyphal mass is formed and from this the progametangia arise in a tong-like fashion. Gametangia are then cut off and fuse to form the zygospore. Maturation of the zygospores is similar to that found in other Mucorales. Mature zygospores can be recognized by the coalescence of numerous small oil droplets into one large one. The zygospore appears to be rather fragile and breaks readily under a cover slip. The broken walls of mature zygospores clearly show the striations illustrated by Poitras for other species of the genus (FIG. 5).

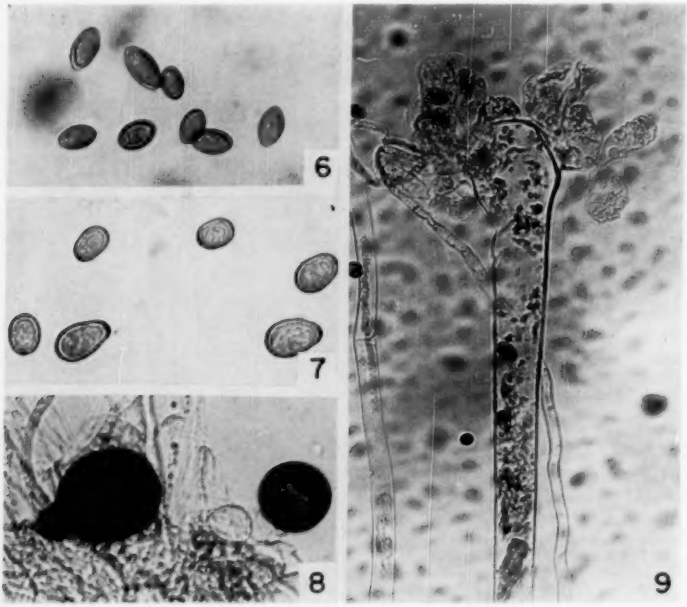
Out of the 27 strains in all available for study, only NRRL 2546 and NRRL 2547 and 2 additional strains proved to be of one mating type while the other 23 belonged to the other mating type.

An interesting observation has been made on the effect of lyophilization of isolates of this species as well as of some of the other species in the genus. Ordinarily, asexual sporulation with *C. circinans* is difficult to obtain. However, when sporangia are produced, lyophilization is quite satisfactory. When lyophil tubes are opened, growth is often more compact and sporulation is much better than before. While sporulation is better, the amount of aerial mycelium appears to be greatly reduced.

IMPERFECT REACTION BETWEEN SPECIES OF CHOANEPHORA

In our attempt to identify one of the members of *Choanephora*, NRRL A-6688, the mating types of *C. conjuncta* NRRL 2560 and NRRL 2561 were mated with it. A-6688 later proved to be an isolate of *C. trispora* (*Blakeslea trispora*) which readily mated with the proper mating types of *C. trispora*. When *C. conjuncta* NRRL 2560 was mated with A-6688, the colonies remained white in reverse and no sexual reaction occurred. However, when NRRL 2561 and A-6688 were mated, pronounced yellow color was formed in the reverse of both colonies at the line of contact between them. No distinct line of dark zygospores was seen, contrary to the case in mating strains of the same species. The colony of A-6688 was restricted and overgrown by NRRL 2561. The reverse of A-6688 became deep yellow in color and when examined at 5 days showed indistinct regions and streaks of gray. Examination of these areas showed numerous dark zygospore-like

objects (FIG. 9). For the purpose of this paper these may be called zygospores although many might have been azygospores. The substrate mycelium in this region was so compact and tough that whether or not all of the spores arose from fusions of gametangia could not be determined. In most respects they resembled zygospores, showing colors of yellow to dark brown and showing definitely striate walls.



FIGS. 6–9. *Choanephora* spp. 6. Conidia of *Choanephora cucurbitarum*. 7. Conidia of *C. conjuncta*. 8. Imperfect zygospores formed between *C. trispora* (NRRL A-6688) and *C. conjuncta* (NRRL 2561). 9. Persistent vesicles of *C. conjuncta*.

Numerous fusions of gametangia and other early stages of zygospore formation could be found in older cultures. One of the characteristics of the mature zygospores was their irregular shape. Often at low power, they appeared to be small pycnidia, the darkened region having extended out along one suspensor. Microscopic examination showed the zygospores to be about 50–60 μ in diameter. The zygospores had, at maturity, a centrally located oil droplet. The mycelium in the region of zygospore formation had much yellow color in its cytoplasm and

was greatly distorted and twisted. The matings were repeated with the same results and we have concluded that imperfect sexual reproduction had occurred.

It seemed of interest also to mate *C. trispora,* A-6688, with *C. circinans,* NRRL 2548. Approximately the same reaction as noted above occurred except that only a very few dark-colored zygospores were formed.

Given known mating types of one species of *Choanephora,* we believe that the mating type of any other strain of any species of the genus can be determined by the difference in yellow pigmentation on the reverse side of the mated colonies and by the formation of imperfect zygospores.

CHOANEPHORA CONJUNCTA

In the treatment of the Choanephoraceae (**3**) the species *C. conjuncta* Couch was recognized as a distinct species. Poitras' conclusion to reduce this species to synonymy with *C. cucurbitarum* was based upon a study of some of the herbarium material which Couch (**1**) had studied at the time he described *C. conjuncta.* Poitras based his conclusion on the presence of striations on the conidia seen in the *C. conjuncta* material. In the light of our study of living material and type material of *C. conjuncta,* we believe that the species should be maintained.

Recently Dr. Julian Miller, University of Georgia, sent us a number of Mucorales isolated from soil. Among these strains was a *Choanephora* which, upon examination, proved to agree almost identically with the description of the species which Dr. J. N. Couch had prepared. Through his courtesy we received some of the type material, which included both conidiophores and zygospores. The material agreed perfectly with that of our isolate, NRRL 2562. Dr. J. N. Couch has examined this strain and has confirmed our identification.

CHOANEPHORA CONJUNCTA Couch, Jour. Elisha Mitchell Sci. Soc. **41**: 143. Pls. 9–11. 1925.

Colonies on SMA for 5–7 days at 25° C rapidly growing, over 1 cm in height, nearly white to Pale Olive-Buff or Ivory Yellow (**6**), deeper yellow on aging; colonies with white fluffy growth and with conidial heads formed early, with the conidial heads later overgrown with sterile mycelium; colony reverse with small wavy zonations, Seafoam Yellow (**6**), becoming more yellow on aging, with the conidial heads seen as dark spots through the reverse side of the colony; odor sickly sweet; conidiophores arising from the substrate mycelium, hyaline, smooth-walled, erect, then collapsing, up to 32 μ in diam., unbranched except

for the vesicular branches arising from the terminal vesicle; primary vesicle hyaline, flattened above, with secondary branches up to 75 μ in length; secondary vesicles persistent (FIG. 8), bearing conidia, with the upper portion collapsing but with the lower portion of the vesicle remaining expanded to give funnel-shaped structures, 2 to over 20 in number; entire conidial head of a conidiophore up to 250 μ in diam.; conidia (FIG. 7) germinating in place, not striate (at least as usually mounted) even under oil immersion, appearing punctate, smooth-walled, purplish-brown, with a distinct point of attachment of about 2.5 μ in diam., oval or obovate, typically obovate, with smaller end at point of attachment, with granular contents, sometimes in clumps, 13–18 $\times$ 9–13 μ; sporangiophores arising from substrate, hyaline, with smooth, granular or roughened wall, non-septate, erect, later collapsing, unbranched, to 8–10 μ in diam., bearing sporangia circinately; sporangia few-spored, brown, splitting into halves, globose, 35–86 μ; sporangial wall transparent, incrusted; columellae hyaline, globose, to 12 μ in diam.; sporangiospores oval, triangular or irregular in shape, with vacuolate or granular contents, usually with two regions from which appendages are attached, 6.5–14 $\times$ 13–25 μ; spore wall smooth, striate; appendages hyaline, numerous, up to 28 μ in length; zygospores (from herbarium specimen) golden brown, globose to bent ellipsoid, heavy-walled, borne in or on the surface of medium, with smooth and clearly striate wall which is divided into three zones, 40–80 μ in diam.; heterothallic; chlamydospores and oidia not seen; growth occurring on PDA at 37° C, but without sporulation above 32° C.

Isolate NRRL 2562 produces thin growth but conidiophores abundantly on Czapek's solution agar. The conidia germinate in place and typically put forth two germ tubes. When grown upon PDA, heavy growth occurs with the yellowish mycelium filling the entire Petri dish. When sterile pumpkin tissue is placed upon Czapek's solution agar, both conidiophores and sporangiophores are produced on both the pumpkin and the agar.

C. conjuncta is unquestionably very closely related to *C. cucurbitarum,* but it can be distinguished by the following points. The conidia (FIGS. 6, 7) of *C. conjuncta* are different in shape, being blunt at either end and typically obovate. Striations on the conidia of *C. conjuncta* are not seen by the usual means of study. The secondary vesicles remain persistent instead of falling off as in *C. cucurbitarum.* This may not be a particularly good characteristic because the conidiophores when just mature on Czapek's solution agar sometimes show most of the vesicles falling off.

The close relationship of this species to *C. cucurbitarum* is shown when NRRL 2562 is mated with the (+) mating type of *C. cucurbi-*

tarum. When mating types of *C. cucurbitarum* are mated at 25° C on PDA, usually by the third day a dark line of zygospores begins to form at the juncture of the two strains. By the fourth day this dark zone of zygospores has extended completely across the plate. Examination of the zygosporic region after one week's growth shows hundreds of zygospores which are uniformly purplish-black and no undeveloped progametangia. The mycelium in this region is devoid of appreciable amounts of yellow color. However, when *C. conjuncta* NRRL 2562 is mated with *C. cucurbitarum* A-6097, at the end of 4 days only a yellow region appears across the plate with no evidence of mature zygospores. After one week in this mating a diffuse gray region develops on the side of the A-6097 colony. The pronounced yellow zone is still clearly evident. Microscopic examination of this region shows some purplish-black zygospores which resemble those above but in far fewer numbers per unit area. In this imperfect reaction, besides the deeply pigmented zygospores there appear others which are colorless through light gray. The cytoplasm of the mycelium in the zone of imperfect reaction contains large amounts of yellow-colored material. Particularly striking are the hundreds of progametangia present which have failed at various stages to develop further. This, it seems to the authors, is supplementary evidence for concluding that *C. conjuncta*, although closely related to *C. cucurbitarum* should still be recognized as a distinct species. Normal zygospores are not formed at all when *C. conjuncta* is mated with *C. trispora*.

Recently we secured cultures of *C. infundibulifera* from Dr. K. Sato, Institute of Fermentation, Osaka, Japan. The two strains have been assigned the numbers, NRRL 2560 (IFO 5987) (+) and NRRL 2561 (IFO 5988) (−). A third strain isolated by Dr. C. B. Pinto from air at Caracas, Venezuela, has also been studied. When the three strains were mated upon PDA at 26° C, zygospores were produced in abundance in six days. The Venezuela strain was determined to be a (−) strain, since it readily mated with NRRL 2560 to give zygospores.

These strains form colonies similar in appearance to other species of *Choanephora*, with white aerial mycelium often tinted yellow. When the colonies of the mated strains meet, a dark zone of zygospores appears across the plate. As the cultures age, the width of the zone of zygospore formation increases up to about 3 cm. The zygospores are formed at the surface or in the substrate although occasionally a few may be seen in the aerial mycelium. However, careful examination of NRRL 2560 showed that sporangia formed sporangiospores which possessed hyaline, thin appendages at their ends, similar to those seen in *C. con-*

juncta. When NRRL 2562 (*C. conjuncta*) was mated with NRRL 2560 which had been received as *C. infundibulifera,* zygospores were formed in abundance and were quite regular in appearance. There was no indication of incomplete fusions and no yellow pigment remained on the reverse side of the line of zygospores as is seen in intraspecific matings. It therefore seems apparent that these strains also represent isolates of *C. conjuncta.*

The zygospores of *C. conjuncta* (NRRL 2560 × NRRL 2561) are produced in the usual fashion in *Choanephora,* with hyphae twisted about each other at the base of the zygospore and with suspensors which are tong-shaped and approximately equal in size. The suspensors are smooth-walled and hyaline or nearly so, often with yellow droplets inside. They may have a diameter up to 22 μ next to the zygospore. The mature zygospores are golden brown to brown in color, mostly globose, though a few are oval in shape, and at maturity contain a large central oil droplet. The zygospore wall is nearly smooth in outline and when examined under oil immersion is clearly marked with striations. The zygospores are typically 36–72 μ in diameter.

DISCUSSION

The conclusion arrived at by Poitras (**5**) to include *Blakeslea* in the genus *Choanephora* seems further justified by the above studies. In addition, both *C. circinans* and *C. conjuncta,* like *C. trispora* and *C. cucurbitarum,* have been shown to have many characteristics in common. The zygospores of all four species are formed in the same fashion and each has zygospore walls marked with striations. Each of these species produces large numbers of zygospores in a distinct line between compatible mating types, and the zygospores are borne in the same location relative to the substrate, namely, in or at the surface of the medium. Asexually the sporangia are of a similar type, characterized by the wall splitting rather than deliquescing and by the occurrence of striate asexual spores and sporangiospores which typically possess long, stiff, hyaline appendages. Colonies of all the species spread rapidly over nutrient agars and are characterized by much sterile aerial mycelium that is yellowish-white in color. Each also is somewhat poor in sporulation on our routine media used for sporulation of Mucorales.

Further evidence of the close relationship of these species to each other is found in their reaction when opposite mating types of different species are mated. For example, a more nearly perfect reaction occurred between *C. trispora* and *C. conjuncta* than between *C. circinans* and *C. conjuncta.*

SUMMARY

Blakeslea circinans Naganishi & Kawakami has been recombined as *Choanephora circinans*. Description of its growth on synthetic mucor agar and its natural distribution are given. The zygospores are reported for the first time and are similar to those observed in the other species of *Choanephora*. Imperfect hybridization between certain species of *Choanephora* is reported. Evidence is presented for maintaining the species, *C. conjuncta* Couch.

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AN ENTEROBRYUS OCCURRING IN THE MILLIPED SCYTONOTUS GRANULATUS (SAY) [1, 2]

ROBERT W. LICHTWARDT

(WITH 14 FIGURES)

The second genus of fungi belonging to the order Eccrinales, whose members live as commensals in the hindguts of Arthropods, was described by Joseph Leidy in 1850 and named *Eccrina*. Two species from different millipeds, *E. longa* and *E. miniliforma*, were the basis for establishing the new genus. *Eccrina* was distinguished from *Enterobryus*, the first genus described belonging to the Eccrinales, solely on the number of terminal cells (sporangia) possessed by the thalli. It has been pointed out (Lichtwardt, **1954**) that this criterion alone is not valid for recognizing the two distinct genera.

Eccrina moniliformis [3] was collected and studied by the writer from the same species of host dissected by Leidy. For reasons discussed later in this paper, *Eccrina moniliformis* is believed to be a species of *Enterobryus* and therefore is transferred to that genus.

MATERIALS AND METHODS

Only a few individuals of the milliped host, *Scytonotus granulatus* (Say),[4] formerly known as *Polydesmus granulatus*, have been dissected by me. The species is widespread in the eastern part of the United States, but apparently does not occur in large numbers in any given area, and it is a small form and rather inconspicuous. The specimens collected came from Champaign and Vermillion Counties, Illinois.

[1] This paper is based upon a portion of a Ph.D. thesis submitted to the University of Illinois in 1954. The author is greatly indebted to Dr. Leland Shanor who supervised this research, and he thanks Dr. J. C. Gilman for reading the manuscript.

[2] Journal Paper No. J-3176 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1300.

[3] In 1853 Leidy corrected the specific epithet from *moniliforma* to *moniliformis*.

[4] I thank Mr. Richard L. Hoffman for identifying specimens of the milliped.

The general method used for dissection of the host and preparation of fungus material for study has been outlined previously (Lichtwardt, **1954**).

OBSERVATIONS

In Leidy's paper of 1850 he described *Eccrina moniliformis* as follows:

"*Eccrina moniliforma.* Filaments hyaline or yellowish, forming a double or treble spiral. Peduncle short. Frond cell filled with globules and granules, except towards its free extremity, where it is filled with granular matter divided into distinct and separate masses, usually a little shorter than broad, and containing each a globular nucleolated nucleus. Divisions progressively passing towards the end into globular cells with granular contents. Divisions and globular cells from 20 to 50 in number.

"Length from 1 to 1½ lines, breadth average 1–1500th in. Divisions of frond cell contents and globular cells from 1–1875th (to) 1–1500th in. Nucleus of cells 1–3750(th) in.

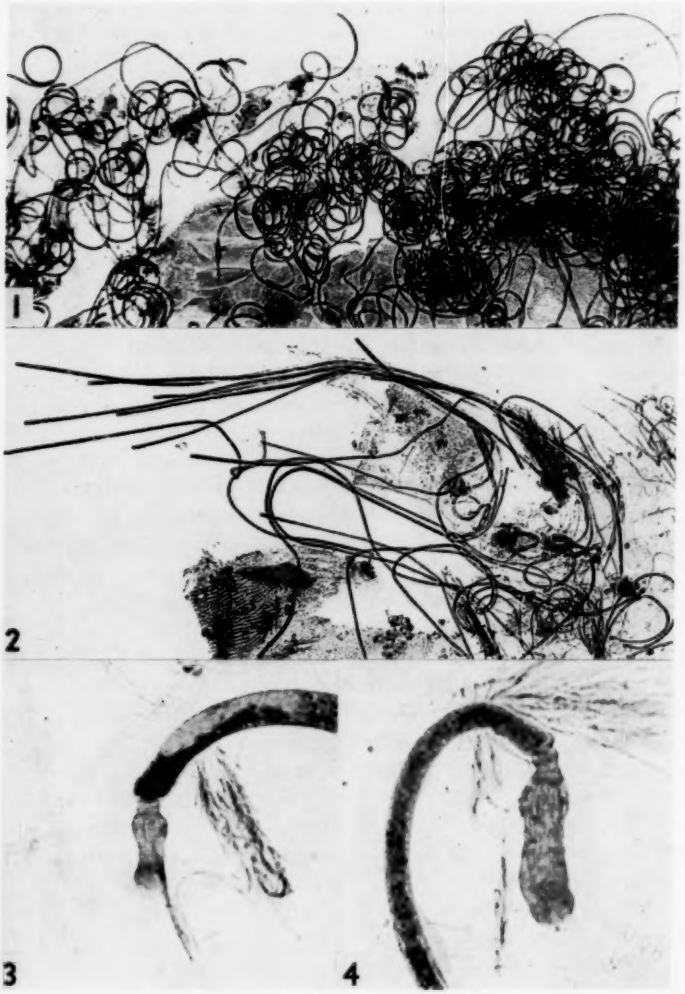
"*Habitat.* Grows in moderate quantity from the mucous membrane of the intestine of 50 per cent. of Polydesmus granulatus."

Eccrina moniliformis also was described in an abbreviated form by Leidy in his paper of 1853, but unlike the treatment accorded other species of Eccrinales in that paper, it was not illustrated.

The spiraled effect of the thalli described by Leidy was observed to a greater or lesser extent in all infected hosts dissected by me. The gut of one host in particular, illustrated in FIG. 1, possessed hyphae with very tight coils and more spiraled than one would expect from Leidy's description. The appearance of the hyphae from other hosts, exemplified in FIG. 2, showed only a slight coiling near the base of the filaments. (It should be pointed out that during mounting of material, such as in FIG. 2, pressure of the coverslip causes some of the spirals to uncoil.) These extremes of spiraling are considered to be variations of habit within the species.

The holdfasts of this species are rather distinct in that they usually have a constriction just below their attachment to the hypha (FIGS. 3, 4). The longer holdfasts almost invariably show longitudinal striations, as can be seen in FIG. 4. As a rule the base of the holdfast does not have a prominent enlargement, and occasional basal disks which do occur are not very large.

Series of sporangia containing uninucleate spores (FIG. 5) are numerous in most hosts and are apparently the only type of spore in *E. moniliformis* seen and described by Leidy. It is interesting that in



FIGS. 1–4. *Enterobryus moniliformis.* 1. Coiled hyphae attached to lining of hindgut of *Scytonotus granulatus,* × 50. 2. Hyphae from another host specimen showing slight coiling near the base, × 50. 3. Holdfast with typical constriction near attachment to thallus, × 600. 4. Longer holdfast with longitudinal striations, × 600.

this species he refers to these cells as having a "globular nucleolated nucleus," for this is one of the rare instances in all of his writings on entophytes in which he mentions the nucleus. In the material which

FIGS. 5–14. *Enterobryus moniliformis.* 5. Row of uninucleate sporangiospores. 6–9. Stages in emergence and encystment of uninucleate sporangiospores. 10. Multinucleate spore in a sporangium. 11. Multinucleate sporangiospore starting to germinate. 12–13. Ellipsoid spores attached to gut lining. 14. Germination of ellipsoid spore. Figs. 5–13, × 600. Fig. 14, × 300.

I have studied these spores have not been seen in series of more than a dozen in a hypha. The dimensions of the spores vary from about 8–15 μ in length by 6–10 μ in width though the comparative volume of the spores is rather constant.

At the time the spores are ready to quit the sporangium they have no distinct wall surrounding them. As they emerge from the sporangium, in some instances they appear to squeeze through a break in the terminal wall (FIG. 6). Outside the sporangium they assume a spherical or slightly oval shape (FIG. 7), and encyst by the formation of a distinct wall (FIGS. 8, 9). The succeeding stages in the life cycle of the spore have not been observed, but they apparently do not form new hyphae directly in the host.

Multinucleate sporangiospores (FIG. 10) in *E. moniliformis,* previously referred to as type A (Lichtwardt, **1954**), are not as common as the uninucleate spores nor as abundant as in many other species of *Enterobryus.* However, their presence has been noted in many instances, and stages in their germination have been observed (FIG. 11). In all cases which I have seen, the multinucleate sporangiospores of *E. moniliformis* lacked the bulbous base which is characteristic in many species of *Enterobryus.*

In addition to the spores just described, small, ellipsoid spores have been found attached to and germinating on the lining of the gut of *Scytonotus* (FIGS. 12–14). They are usually 4-nucleate, and germinate to produce hyphae in a manner typical of multinucleate sporangiospores of type A. The origin of these ellipsoid spores has not been determined, for no hyphae have been found in the hindgut producing spores of this type. I have found similar ellipsoid spores in five other unpublished species of *Enterobryus.*

Since the observations reported in this paper supplement those of Leidy, and because, for reasons stated below, it is believed this species should be transferred to the genus *Enterobryus* Leidy, the following description of the species is offered:

Enterobryus moniliformis (Leidy) comb. nov.

Attached to the lining of hindgut of the milliped *Scytonotus granulatus* (Say). Hyphae spiraled throughout their length, or curved or spiraled only at the base. Length of hyphae up to 3 mm, usually much shorter; diameter typically 6–12 μ. Cytoplasm hyaline and somewhat granular. Holdfast characterized by a constriction near the attachment to the hypha; generally 12–35 μ long by about 10 μ wide; longer holdfasts usually striated longitudinally. Multinucleate sporangiospores

about 50–60 μ long by 5–8 μ wide. Uninucleate sporangiospores about 8–15 μ long by 6–10 μ wide. Ellipsoid spores approximately 19 × 5 μ.

The measurements given are generally smaller than those published by Leidy. A slight discrepancy in the same direction appears in both *Enterobryus elegans* and *E. attenuatus* when a comparison is made between the descriptions by Leidy and by myself.

DISCUSSION

The only distinction made by Leidy between the genera *Eccrina* and *Enterobryus* was that thalli of *Eccrina* produced a succession of terminal cells (sporangia), while *Enterobryus* produced only one to three such cells (Leidy, **1850**). I have shown (Lichtwardt, **1954**) that *Enterobryus elegans*, Leidy's original species, produces up to a dozen or more terminal sporangia, and that the number of sporangia depends upon ontogenetic circumstances and consequently is not a valid generic characteristic. Other species of *Enterobryus* studied by me support this statement. In other morphological respects I can find no salient generic differences between the species reported in this paper and other species of Eccrinales belonging to the genus *Entrobryus* from millipeds. Whether or not Leidy's only other species of *Eccrina*, *E. longa*, justifies conservation of the genus *Eccrina* has not been determined, for I have not seen that fungus. However, on the basis of Leidy's description and illustrations, *E. longa* also would appear to be a species of *Enterobryus*.

SUMMARY

Eccrina moniliformis Leidy from the hindgut of the milliped *Scytonotus granulatus* (Say) was studied, and unpublished features of its morphology are described and illustrated. The fungus is believed to belong to the genus *Enterobryus*, and a transfer of this species is recommended, resulting in the new combination *Enterobryus moniliformis*.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY
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LITERATURE CITED

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NEW AND UNIDENTIFIED SPECIES OF SYNCHYTRIUM. V [1]

JOHN S. KARLING

(WITH 9 FIGURES)

Since the publication of the preceding papers in the present series on new and unindentified species of *Synchytrium*, several additional members have been found in herbaria in this country and elsewhere, and the present contribution is a description of them. As noted in the previous papers, all species were studied first from the herbarium material after which heavily infected bits of the hosts were thoroughly soaked in water, fixed in a vacuum to remove air, embedded, sectioned at 7 μ, and stained. Although the host tissue was markedly shrunken, the fungi and their galls were sufficiently well preserved to determine many of their characteristics. Nevertheless, the dimensions of the prosori, sori, sporangia and resting spores given below are probably smaller than they are in living material. Many of the species described here are not given specific names because their life cycles are not fully known. It is not worth while, in my opinion, to give them names which in the future may prove to be synonyms of longer-known species. Nevertheless, they are described to call collectors' attention to their occurrence and to provide a basis for comparisons with other species.

S. linariae sp. nov.

Prosoris ovalibus 40–90 × 60–102 μ, vel subsphaericis, 60–80 μ, soris subsphaericis, 60–90 μ, ovalibus, 42–95 × 68–108 μ, vel reniformibus, 46–55 × 67–86 μ. Sporangiis sparsis, polyhedris, 19–40 μ, intus flavis. Zoosporis oblongis, 1.8–2.2 × 3–3.5 μ. Sporis perdurantibus sphaericis, 78–130 μ, vel ovalibus, 60–115 × 84–132 μ, parietibus laevibus, fusci, 4–5.5 μ crassis; germinatione ignota.

Specimen typicum in Herb. Univ. Fla., U.S.A. conservatum.

[1] This study has been supported by a grant from the National Science Foundation. I am very grateful to Drs. G. B. Cummins of Purdue Univ., H. C. Greene, Univ. of Wisconsin, I. Mackenzie Lamb of Harvard Univ., Jeane Pellier of the Mus. Natl. d'Hist. Nat., Paris, A. H. Steward of Ore. State Coll., and C. G. Shaw of Wash. State Coll., for loan and gifts of herbarium material. Dr. George F. Weber of the University of Florida has sent me living material of *S. linariae* from time to time, and I am particularly grateful to him for this courtesy.

Prosori ovoid, 40–90 × 60–102 μ, or subspherical, 60–80 μ, lying above sorus when empty and collapsed. Sori formed beneath prosori, subspherical, 60–90 μ, ovoid, 42–95 × 68–108 μ, or almost hemispherical to reniform, 46–55 × 67–86 μ. Plug between empty prosorus and sorus 10–12 μ diam. by 5–8 μ thick. Sporangia 15–35 per sorus, polyhedral, 19–40 μ in greatest diam., with orange contents and thin hyaline walls. Zoospores oblong while actively motile, 1.8–2.2 × 3–3.5 μ, with a refringent orange globule. Resting spores filling only part of host cell and usually solitary, spherical, 78–130 μ, or ovoid, 60–115 × 84–132 μ, with a smooth amber-brown wall, 4–4.5 μ thick; enveloping residue yellowish-brown, sparse or abundant, usually in the form of globules, sometimes fused, compact, and up to 12 μ thick; germination unknown.

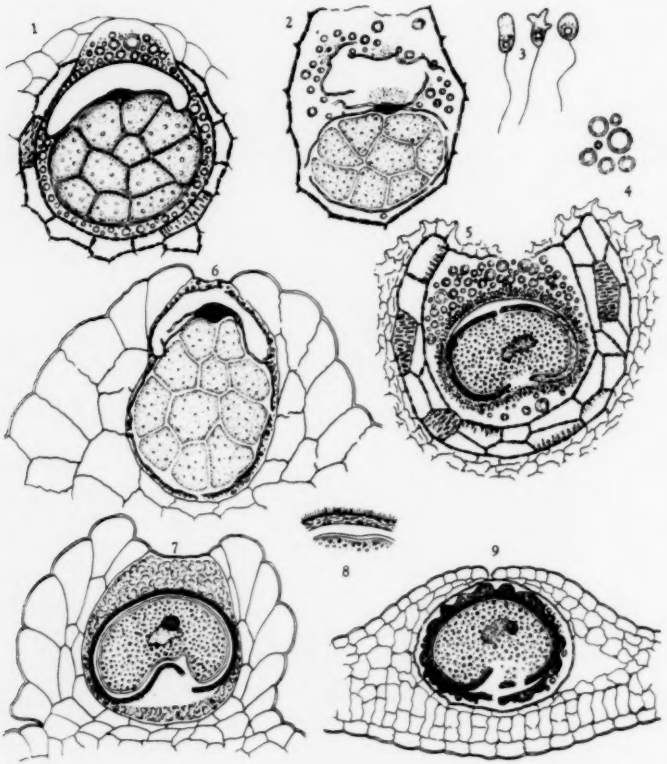
Compositely dihomeogallic, galls abundant, sometimes separate but usually crowded and confluent, embedded in and enveloped largely by host tissue, usually not protruding conspicuously, hard and woody, somewhat cup- or bowl-shaped in dried specimens, usually with a broad pore or apex which usually invaginates as galls dry out. Sporangial galls yellowish, 120–192 μ high by 132–252 μ broad, becoming cupulate after dehiscing. Resting-spore galls brownish, 168–240 μ high by 170–210 μ broad with a depressed apex when dry. Sheath consisting of an outer layer of thin-walled cells and an inner layer of enlarged cells whose walls are thick and lignified and have numerous sclariform openings.

On leaves, petioles and stems of *Linaria canadensis*, Gainesville, Florida, U.S.A., causing thickening of lower leaves and petioles, and large white or green tumors, up to 1.5 cm diam. at the collar or base of stem.

The herbarium specimens of this species were identified as *S. aureum* by Dr. E. West, but this is incorrect because the latter species is short-cycled and develops only resting spores. That *Synchytrium linariae* is long-cycled has been confirmed from sections of the herbarium specimens as well as from living material kindly sent to me by Dr. George F. Weber of the University of Florida. It is a comparatively small species and produces relatively few and usually small sporangia. The prosori and sori also are usually small and like the resting spores occupy only a part of the enlarged and somewhat pyriform host cell (FIGS. 1, 2, 5).

Most of the galls which it induces are confluent, largely embedded in the host tissue and do not protrude conspicuously (FIGS. 1, 2, 5). However, when they occur singly and separately they are usually mound-shaped or subhemispherical on the surface of the host. This is particularly true of the sporangial galls. Most of them are characteristically hard and woody in texture and well-preserved in sections of the

herbarium material. In dissection of living material they "feel" like grains of sand and come out of the host tissue almost in entirety. This texture is due chiefly to the thick and lignified walls of the inner sheath cells. These walls are perforated by numerous scalariform perforations



FIGS. 1–5. *S. linariae*. 1. Portion of a living sporangial gall with empty prosorus and sorus of sporangia, × 80. 2. Infected cell from herbarium material with empty prosorus and sorus of sporangia; infected cell wall lignified and perforated, × 76. 3. Zoospores, × 400. 4. Partially hollow globules of residue, × 100. 5. Portion of resting-spore gall with resting spore showing thickness of inner layer of lignified sheath cells, × 89. FIGS. 6–8. *S. echinulatum*. 6. Sporangial gall with empty prosorus and sorus of sporangia, × 87. 7. Resting-spore gall with echinulate resting spore, × 75. 8. Magnified view of echinulate exospore and retracted endospore, × 180. FIG. 9. *S. davisi*. Resting-spore gall in lower part of leaf with resting spore, × 187.

(FIGS. 1, 2, 5) which are very similar to those described by me (**1955**) for *S. geranii* and other species. The wall of the infected or host cell also may be thickened, lignified and perforated in the same manner (FIG. 2). The perforations may be so numerous that the walls frequently have a beaded appearance (FIGS. 1, 2, 5) in cross sections. The layer of thick-walled cells usually does not extend over the upper part of the infected cell (FIG. 1), and as the galls dry out the apex may collapse or invaginate (FIGS. 2, 5). As a result, undehisced galls in the herbarium material often appear to be cupulate. The thickness of the lignified layer varies somewhat. It is usually thicker (FIG. 5) in resting-spore galls than in the sporangial galls (FIG. 1), and rarely it may be lacking entirely in the latter. The prosori, sori and resting spores are usually enveloped by yellowish-brown residue (FIGS. 1, 2, 5) which may be relatively sparse or abundant. This residue is usually in the form of globules or partially hollow spheres, as shown in FIG. 4.

Linaria canadensis is a new host for *Synchytrium* but *S. aureum, S. linderniae, S. globosum, S. johansonii* and *Synchytrium* spp. have been reported on other species of the Schrophulariaceae. However, of these only *S. linderniae* is long-cycled, but its initial cell develops directly into a sorus of sporangia, according to Ito and Tokunaga's (**1935**) description. *Synchytrium linariae,* therefore, is clearly different from it and is the only known species on members of this host family whose initial cell functions as a prosorus. On these grounds it is placed temporarily in the subgenus *Microsynchytrium,* pending discovery of the method by which its resting spores germinate.

S. echinulatum sp. nov.

Prosoris subsphaericis, 84–98 μ, vel ovalibus, 80–105 $\times$ 66–120 μ. Sorus subsphaericis, 90–110 μ, vel ovalibus, 80–95 $\times$ 90–130 μ. Sporangiis polyhedris, 30–52 μ, intus flavis. Sporis perdurantibus subsphaericis, 70–96 μ, vel ovalibus, 60–96 $\times$ 102–115 μ, parietibus echinatis fuscis, 3.2–5 μ crassis; germinatione ignota.

Specimen typicum in Farlow Crypt. Herb., Harvard Univ., U.S.A. conservatum.

Prosori subspherical, 84–98 μ, or ovoid, 80–105 $\times$ 96–120 μ, with an amber wall, lying above or slightly to one side of sorus when empty and collapsed. Sori formed beneath the prosori, subspherical, 90–110 μ, or ovoid, 80–95 $\times$ 90–130 μ with a smooth, light-amber wall, up to 2 μ thick. Plug between empty prosorus and sorus, 15–18 μ diam. by 9–12 μ thick. Sporangia 30–62 per sorus, polyhedral, 30–52 μ in greatest diam., with yellowish-orange content and hyaline walls. Zoospores unknown. Resting spores usually solitary, rarely 2 in a cell, partly filling host cell and enveloped by a dense and fairly compact layer of reddish-brown residue which usually fills remainder of host

cell, subspherical, .70–96 μ, or ovoid, 60–96 × 102–151 μ; exospore amber-brown, 2.8–3.5 μ thick, and covered by short, 1.8–3 μ, spines; endospore hyaline, 1.6–2 μ thick, and usually contracted away from exospore in fixed and stained sections; germination unknown.

Compositely dihomeogallic, galls abundant on leaves, petioles and stems, separate and scattered, but usually crowded and confluent to form crusts, occasionally compound. Sporangial galls highly mound-shaped or almost hemispherical with a broad or narrow apical pore, 160–180 μ high by 250–310 μ broad; sheath 2–4 cells thick, sheath cells greatly enlarged. Resting-spore galls usually brilliantly lavender-red, 150–178 μ high by 275–315 μ broad; sheath 2–4 cells thick, sheath cells greatly enlarged, thin-walled and usually elongate outward.

On *Godetia amoena*, La Honda, San Mateo Co., Calif., U.S.A.

The specimens of this species from the herbarium of T. S. Brandegee (no. 4260) are labeled *S. fulgens*, but no collector is indicated on the packet of material. *Synchytrium echinulatum* is characterized primarily by echinulate or spiny resting spores. The spines on the exospores are very numerous (FIGS. 6, 7) but only 1.8–3 μ long, and for this reason they may be overlooked under low magnifications. Usually, the enveloping residue obscures them, but when this material is stripped or torn off in sectioning the spines are readily recognizable under very high magnifications. Since discovering this characteristic, I have restudied the resting spore walls of the long-cycled species which I (**1955**, **1956**) described on various species of the Onagraceae to determine whether or not they are echinulate also. All of them have non-echinulate resting spores and differ in this respect from *S. echinulatum*.

Most of the sporangial galls in Brandegee's material had dehisced, but a few of them were intact, with an empty prosorus and a sorus of sporangia. One of these galls is shown in FIG. 6, which indicates that the initial cell of *S. echinulatum* has functioned as a prosorus. No migration stages of the protoplasm out of the prosorus were found, but in all of the intact sporangial galls an empty and collapsed vesicle was found above the sorus. Also, a conspicuous plug connects this vesicle with the sorus, and I have found this structure in all species whose initial cell functions as a prosorus. On this basis as well as on its long cycle of development, *S. echinulatum* is placed temporarily in the subgenus *Microsynchytrium*, but its final inclusion here depends on whether or not the resting spores function as prosori when they germinate.

Synchytrium davisii sp. nov.

Sporis perdurantibus subsphaericis, 42–140 μ, vel ovalibus, 72–80 × 110–130 μ; parietibus laevibus, 3–4 μ crassis; germinatione ignota.

Specimen typicum in Herb. Univ. Wisc., U.S.A. conservatum.

Resting spores usually solitary, rarely 2 in a cell, not filling host cell completely, subspherical, 42–140 μ, or ovoid, 72–80 × 110–130 μ, with a smooth, amber wall, 3–4 μ thick, and faintly yellow to hyaline contents; enveloping residue usually sparse, sometimes fairly abundant, crumbly or globular, adhering closely to spore wall so that it may appear coarsely verrucose; germination unknown.

Compositely monogallic, resting-spore galls abundant on lower side of leaf, scattered and separate or sometimes crowded and confluent, tan to light-brown, small and inconspicuous, embedded in the leaf tissue and protruding only slightly, lowly mound-shaped, 102–120 μ high by 108–168 μ broad with a narrow apical pore; sheath 1–3 cells thick, sheath cells small and thin-walled.

On *Rubus hispidus* and *R. triflorus*, Millston, Wisc., U.S.A. (leg. J. J. Davis, 9–27–1912).

This species is named in honor of the late Dr. J. J. Davis, who collected it and numerous other species of *Synchytrium* in Wisconsin. He identified it as *S. aureum*, which he collected on *R. villosus* and *R. triflorus* from other localities in Wisconsin. The galls caused by *S. aureum* on the latter hosts are quite large, 364–520 μ high by 398–572 μ broad with a sheath 4–6 cells thick, protrude conspicuously and are largely superficial like the ones I (**1956**) described on *Rubus* sp. and *R. trivialis* from Louisiana. Those caused by *S. davisii*, on the other hand, are minute, lowly mound-shaped (FIG. 9), 102–120 μ high by 108–168 μ broad, embedded in the leaf, and look like small tan to light-brown specks on the leaves. Since it occurs on the same hosts, *R. triflorus* and *R. hispidus*, as *S. aureum* these differences are significant, in my opinion. The dimensions of its resting spores fall within the range of those reported for *S. aureum*, but their content is faintly yellow to hyaline in contrast to the yellow and orange content of *S. aureum*. However, it is difficult to evaluate the significance of this difference in dried specimens because it may be influenced by drying and long storage in herbaria.

As noted previously the galls occur on the lower surface of the leaves and are embedded largely in the mesophyll tissue (FIG. 9) and usually extend up to the palisade layer. Sometimes, however, the enlarged infected cell spreads the palisade cells apart and extends to the upper epidermis. The lateral sheath cells as well as those around the apex of the infected cell are derived largely from divided mesophyll cells, and those around the base of the host may have come from the palisade layer. Fairly often, the expanding host cell splits and separates the mesophyll layer as is shown at the right in FIG. 9, and in such case sheath cells may be lacking on the lateral surface of the infected cell.

The epidermal cells at the apex of the gall are usually smaller than normal, which suggests that they may have divided without subsequent enlargement.

Synchytrium sp. on *Thlaspi alpestris*

Resting spores usually solitary, sometimes 2–3 in a cell, filling it almost completely, predominantly egg-shaped or elongate with tapering ends, 98–132 × 166–224 μ, or oblong, with rounded ends, 88–108 × 210–220 μ, sometimes subspherical, 102–144 μ, to ovoid, 90–108 × 120–136 μ, with a light-amber, smooth wall, 2.8–3.6 μ thick, and brilliantly yellow content; enveloping residue sparse or lacking; germination unknown.

Compositely monogallic, resting-spore galls separate and scattered or crowded and confluent, yellowish-green, large, protruding conspicuously, largely superficial and almost hemispherical on host, 320–416 μ high by 420–600 μ broad at base; sheath 3–6 cells thick, frequently 3-layered.

On leaves, petioles and stems of *Thlaspi alpestris,* Hahn's Peak, 10,000 feet alt., Columbine, Colo., U.S.A. (leg. G. B. Cummins, 8–6–1956; spec. in Arthur Herb., Purdue Univ.).

The galls caused by this species are usually quite large and resemble those induced by *S. lepidii* on *Lepidium virginicum.* The sheath is frequently 3-layered with the inner and outer layers composed of enlarged and relatively thin-walled cells. The cell walls of the middle layer are very thick and lignified and thus stand out sharply in stained sections. However, this layer varies considerably in thickness and continuity. In some galls it is continuous around the inner layer and infected cell, and in others it may be interrupted. Sometimes it may be relatively broad and include the outer cells around the apex of the galls. Occasionally, only part of cell walls are thickened and lignified. In the presence of this thick-walled layer, the galls on *T. alpestre* resemble those caused by *S. lepidii,* but in the latter's galls the lignified layer is much thicker. This difference, however, may not prove to be significant. More important is the similarity in shape and size of the resting spores, and for this reason I believe the fungus on *T. alpestre* is identical with *S. lepidii.*

Thlaspi alpestre is a new host for *Synchytrium,* but another species, *T. rotundifolium,* is host to *S. (aureum) infestans* in Switzerland, according to Rytz (**1907**). Possibly, the two fungi on these hosts may prove to be closely related. *Synchytrium (aureum) infestans* is an alpine form of *S. aureum* whose primary host is *Hutchinsia alpina,* but it will attack *T. rotundifolium* growing among infected *H. alpina* plants.

It was found in a moist environment at an altitude of 6600 to 7500 feet, and Rytz believed that its resting spores germinate and produce zoospores in melting snow. The Colorado fungus on *T. alpestre* was collected at an altitude of 10,000 feet, and apparently is an alpine species also. The two fungi thus occur in similar types of environments, but whether or not they are identical is uncertain at present. Rytz figured and described the resting spores of *S.* (*aureum*) *infestans* as spherical or ellipsoidal, 78–138 μ (av. 108 μ) with a bright-brown exospore, 3–4 μ thick, a hyaline endospore, 2–3 μ thick, and golden-orange content. They fill only a part of the greatly enlarged host cell and are not enveloped by residue. The spores of the fungus on *T. alpestre*, on the other hand, are somewhat larger and mostly citriform to elongate with tapering ends and have a thinner wall and yellow content.

In addition to these two fungi and *S. lepedii*, several other species, *S. cruciferarum*, *S. dendriticum*, *S. drabae*, *S. lacunosum* and *Synchytrium* sp., have been reported on members of the Cruciferae. *Synchytrium cruciferarum* and *S. dendriticum* were found to be invalid by the author (**1955b**, **c**), and *S. lacunosum* is a long-cycled species (Karling, **1956a**). *Synchytrium drabae* on *Draba aizoides* produces small, 28–94 μ, resting spores and may be simply monogallic, or half-, or fully compositely monogallic in relation to its host. It differs, thus, quite markedly from the species on *T. alpestre*, and does not appear to be closely related to the Colorado species.

Synchytrium sp. on *Cardamine cordifolia*.

Resting spores usually solitary, filling host cell, spherical to subspherical, 130–162 μ, with a smooth, yellowish-amber wall, 3.5–4.2 μ thick, and yellow content; enveloping residue sparse, in the form of globules; germination unknown.

Compositely monogallic, resting-spore galls usually separate on leaves, crowded and confluent on stems to form crusts, greenish-yellow to brown, large, protruding and largely superficial, but with base embedded in leaf, hemispherical, or highly mound-shaped 360–480 μ high by 456–502 μ broad; sheath 6–8 cells thick, sheath cells globular, greatly enlarged and thin-walled.

On leaves and stems of *Cardamine cordifolia*, Cumberland Pass Road, Pitkin, Colo., and Kebler Pass, Crested Butte, Colo., U.S.A. (leg. G. B. Cummins, 8–22–1956; spec. in Arthur Herb., Purdue Univ.).

The galls induced by this species resemble those caused by *S. macrosporum* and the fungus described above on *Thlaspi alpestris*. The sheath is unusually thick, so that in longitudinal sections the infected

cell looks quite small in comparison with the size of the gall. However, its resting spores are spherical to subspherical in contrast to the elongate shape of those of the species on *T. alpestre* and *Synchytrium lepedii*. *Cardamine cordifolia* is a new host for *Synchytrium*, but *C. amara*, *C. pratensis* and *C. bulbosa* are hosts for *S. aureum*, according to Schroeter (**1885**) and Greene (**1948**) in Germany and Wisconsin, U.S.A. *Cardamine* sp. is parasitized by a fungus which Spegazzini (**1909**) called *S. cruciferarum*, but as I showed (**1955b**) it is not a species of *Synchytrium*. Schroeter did not describe his *S. aureum* on *Cardamine* species, but I have studied specimens (Rabenh. fungi europ. exsi. no. 1460) which Schneider collected, 5–1870, on *C. pratensis* at Liegnitz, Silesia. This is probably the collection on which Schroeter based his 1885 report. On this host the galls are scattered and separate or confluent, lowly mound-shaped or subhemispherical, 120–144 μ high by 168–240 μ broad, with a sheath 2 to 4 cells thick. Accordingly, they are less than half the size of those on *C. cordifolia* in Colorado. The spores are subspherical, 80–98 μ, or ovoid, 78–84 × 86–94 μ, with a thin, smooth, amber wall, 2.8–3 μ, fill the host cell completely, and are not enveloped by residue. The cytoplasm of the spores is densely alveolar but lacks the dense bodies or granules which are commonly present in mature spores. Therefore, the spores look as if they are immature. Through the courtesy of Dr. H. C. Greene, I have studied the species which he collected on *C. bulbosa* in Wisconsin. However, in this material also the galls and spores are immature, so that an accurate comparison is impossible. Probably, the Wisconsin fungus may prove to be identical with the one collected by Schneider.

Synchytrium sp. on *Penstemon whippleanus*

Resting spores solitary or up to 5, filling host cell only partly, predominantly spherical to subspherical, 60–130 μ, with a smooth or slightly wrinkled, amber wall, 3.8–5 μ thick, and yellow content; enveloping residue scarce, usually lacking; germination unknown.

Compositely monogallic, resting-spore galls mostly confluent and forming irregular heaped-up masses on leaves, low and relatively inconspicuous, greenish-yellow, separate galls 108–192μ high by 132–218 μ broad, sheath 1–3 cells thick; inner periphery of host cell wall with numerous tylose-like plugs.

On leaves of *Penstemon whippleanus*, Hahn's Peak, 10,500 feet alt., Columbine, Colo., U.S.A. (leg. G. B. Cummins, 8–6–1956; spec. in Arthur Herb., Purdue Univ.).

In most of the infected cells numerous tylose-like plugs are present in the inner periphery of the wall. These are conical to mound-shaped, 8–13 μ high by 10–15 μ broad, and stain deeply like the cell wall. Strands of cytoplasm often connect them with the surface of the spore. The nature of these plugs cannot be determined fully from the herbarium material, and further study of them in living specimens must be made.

Four unidentified species were reported by the author (**1956a**) on *Penstemon* sp., *P. ovatus*, *P. glaber*, and *P. globosus* from California, Colorado, Idaho, and Wyoming, but this is the first species to be found on *P. whippleanus*. It may prove to be identical with the species on *P. glaber*, which occurs in Colorado also.

Synchytrium sp. on *Helenium hoopesei*

Resting spores solitary, not filling host cell completely, spherical, 110–138 μ, or ovoid, 90–115 × 110–120 μ, with a smooth wall, 3.8–4.5 μ thick, and yellowish content; enveloping residue scarce; germination unknown.

Compositely monogallic, resting-spore galls abundant on both surfaces of leaf, usually separate, sometimes crowded and confluent, lavender-violet, protruding conspicuously, almost hemispherical to highly mound-shaped with a narrow apical pore, 240–300 μ high by 276–372 μ broad; sheath 3–5 cells thick, usually 3-layered.

On leaves of *Helenium hoopesei*, Kebler Pass, Crested Butte, Colorado, U.S.A. (leg. G. B. Cummins, 8–14–1956; spec. in Arthur Herb., Purdue Univ.).

This is the first species to be found on *Helenium*, and the galls which it induces are smaller but very similar structurally to the ones caused by the species on *Thlaspi alpestre*. The sheath is frequently three-layered with the middle layer consisting of cells with thick and lignified walls. The resting spores of this fungus, however, are usually smaller than those of the fungus on *T. alpestre* and not predominantly egg-shaped or elongate. In this respect they differ markedly.

Synchytrium sp. on *Helianthemum* (?) sp.
S. Helianthemi Poirault, in herb.

Resting spores usually solitary, rarely 2–3 in a cell, occupying $\frac{1}{3}$ to $\frac{1}{2}$ of host cell, predominantly ovoid, 38–75 × 54–96 μ, subspherical, 50–80 μ, with a smooth, amber wall, 3.5–4.2 μ thick, and hyaline contents; enveloped by dense lavender-red residue which fills remainder of cell; germination unknown.

Simply monogallic, resting-spore galls separate and scattered, dark lavender-red, sessile, almost spherical, 162–183 μ, slightly ovoid, 172–180 × 192–204 μ, sometimes almost plano-convex, 156–170 × 183–190 μ; with a smooth hyaline wall, 3.5–4.8 μ thick, filled with lavender-red sap and residue.

On sepals, leaves and petioles of *Helianthemum* (?) sp., Collines de Biot. (Les Aspres) France (leg. G. Poirault, 4–1916; spec. in Mus. Nat. d'Hist. Naturelles, Paris).

No host name is given on the packet of material, but inasmuch as Poirault named the fungus *helianthemi* I am assuming that the host is a species of *Helianthemum*. So far as I know this fungus has not been diagnosed or described under the binomial *S. helianthemi*. Accordingly, my (**1946d**) *S. helianthemum* has priority of name and is distinctly different from Poirault's species. The latter is short-cycled and develops only resting spores in simple unicellular galls, whereas *S. helianthemum* is long-cycled and compositely dihomeogallic.

In the herbarium material the galls of Poirault's fungus are collapsed, invaginated and look somewhat like dark shriveled insect eggs. However, when soaked in water for 3 hours they swell up and assume the shapes described above. They are sessile on the host and consist of a greatly expanded epidermal cell. In the latter respect they are basically similar to the galls caused by *S. myosotidis, S. cupulatum, S. potentillae, S. echii, S. namae, S. shawii, S. rubrocinctum, S. pyriforme, S. musicola, S. scirpi, S. punctatum, S. athyrii* and *S. nyctanthidis* which also are short-cycled and develop only resting spores. However, the resting spore content of Poirault's species is hyaline, and on this basis it is to be compared only with the last seven species named above, which are commonly included in *Leucochytrium*. Of these species it resembles *Synchytrium rubrocinctum* Magnus on *Saxifraga granulata* and *S. cernua* in Germany, Sweden and Canada (Karling, **1956c**). However, its identity with Magnus's species will not be certain until it has been studied more intensively from living material.

Synchytrium sp. on *Knautia sylvatica*

Prosori ovoid, 75–90 × 110–130 μ, lying in base of host cell when empty and collapsed. Sori formed above prosorus, subspherical, 90–115 μ, or ovoid 86–98 × 112–140 μ; plug between empty prosorus and sorus 8–12 μ thick by 15–18 μ diam. Sporangia 15–40 per sorus; polyhedral, 34–52 μ in greatest diam., exceptionally large ones up to 72 μ, with orange-yellow content and thin hyaline walls. Zoospores unknown. Resting spores usually solitary, not filling host cell completely

and enveloped by a small amount of residue, usually ovoid, 36–75 × 66–120 μ, with a smooth wall, 3–4.5 μ thick; germination unknown.

Compositely dihomeogallic, galls abundant and usually separate and scattered, confluent on veins of leaf. Sporangial galls light-yellow to almost hyaline, occasionally compound, 96–127 μ high by 168–216 μ broad at base with a broad apical depression which exposes about ¼ of upper surface of infected cell; sheath 1–3 cells thick, sheath cells thin-walled. Resting-spore galls dirty-brown, 80–108 μ high by 140–192 μ broad at base; sheath 1–2 cells thick.

On leaves and petioles of *Knautia sylvatica*, France (leg. Ambert, 7–24–1901; spec. in herb. Mus. Nat. d'Hist. Nat. Paris).

This species is labeled *S. succisae*, but it appears to be different in several respects. In the material available it forms fewer but larger sporangia, and the induced galls are much smaller and only occasionally compound. However, its prosorus lies in the base of the infected cells as in *S. succisae*, and its resting spores are fairly similar in size to those of the latter species.

Synchytrium sp. on *Pyrohopappus* sp.

Sori subspherical, 78–96 μ, or ovoid, 60–108 × 78–150 μ. Sporangia 2–26 per sorus, polyhedral, 37–66 μ in greatest diam., exceptionally large ones 70–85 μ, with orange-yellow content and hyaline walls which are sometimes thickened at the angles. Resting spores usually solitary, sometimes 2, usually not filling host cell completely, subspherical, 48–60 μ, ovoid, 42–54 × 65–84 μ, small ones 24–31 × 30–38 μ, with amber-brown exospores 3.8–4.7 μ thick, whose surface is reticulate, and thin hyaline endospores; enveloping residue usually sparse; germination unknown.

Compositely dihomeogallic, rarely diheterogallic, galls abundant on both surfaces of leaves and frequently forming extensive, slightly raised, dark lavender-red or purplish areas when confluent, separate and scattered or crowded and confluent, embedded largely in host tissue and not protruding conspicuously. Sporangial galls subhemispherical, 84–124 μ high by 130–168 μ broad at base; looking like minute volcanoes with craters after dehiscing; sheath 1–3 cells thick; upper part of infected cell exposed. Resting-spore galls subhemispherical to lowly mound-shaped, 60–110 μ high by 120–145 μ broad at the base; sheath 1–3 cells thick; occasionally simple and unicellular when crowded.

On leaves and petioles of *Pyrohopappus* sp., Corvallis, Oregon, U.S.A. (leg. 3–19–1912, collector unknown; spec. no. 7203 in herb. Ore. State Coll.).

Pyrohopappus, the false dandelion, is a new host for *Synchytrium.* No evidence of a prosorus was found in the fixed and stained sections of the fungus on it, which indicates that the initial cell or thallus develops directly into a sorus of sporangia. In this respect and so far as it is known this species resembles *S. taraxaci* and other similar species which occur on the Compositae, with the exception that the sori are smaller. Should its resting spores be found to function as sporangia in germination and give rise directly to zoospores it will belong in the subgenus *Eusynchytrium.* The surface of its resting spores is distinctly reticulate in appearance, and the reticulae are frequently in the shape of regular or irregular pentagons or hexagons. In this respect the resting spores are very similar to those of *S. innominatum* on *Agroseris grandiflora* and the unidentified species which I (**1956b**, figs. 19, 31) described on *Microseris aphantocarpa, M. biglowii* and *Scorzonella laciniata* from California. At that time I believed that the reticulate appearance was due to a closely adhering layer of cytoplasmic residue, but the discovery of its presence in the species on *Pyrohopappus* also, suggests that it might be a distinct spore-wall characteristic.

Synchytrium sp. on *Campanula americana*

Resting spores usually solitary, sometimes 2–3 in a cell, filling it almost completely, almost spherical, 90–110 μ, or ovoid, 87–95 $\times$ 102–120 μ, with a smooth, dark brown wall, 4.5–5 μ thick, and light yellow content; enveloping brown residue usually sparse and crumbly; germination unknown.

Compositely monogallic, resting-spore galls abundant on all organs of plant, usually confluent and forming crusts on stunted and aborted leaves, lavender to purplish, not protruding conspicuously, lowly and broadly mound-shaped or subhemispherical on surface of leaf with a narrow apical depression, 132–156 μ high by 240–360 μ broad at base; sheath 3–5 cells thick, sheath cells enlarged.

On leaves, petioles and stems of *Campanula americana,* Paradise Valley, Tacoma, Washington, U.S.A., causing thickening and stunting of heavily infected organs (leg. E. W. D. Holway, 7–25–1901; spec. in Farlow Crypt. Herb., Harvard Univ.).

Campanula americana is a new host for *Synchytrium,* and the fungus on it is labeled *S. aureum.* However, when fully known it may prove to be identical with *S.* (*aureum*) *vulgatum* which Rytz (**1907**) described on *C. scheuchzeri* in Switzerland. The size and shape of its resting spores are similar to those of *S. vulgatum,* but the galls which they induce are considerably smaller. This difference, however, may be due

to differences in reaction potential of the hosts. Rytz found that *S. vulgatum* will attack *Homogyne alpina, Phyteuma hemisphericum* and *Chrysanthemum leucanthemum* var. *montanum* as secondary hosts, and that the galls (see his figs. 8, 9a, 9b) may vary in size on the different hosts. It may be noted here also that *S. aureum* was reported on *C. patula* and *C. rotundifolia* in Germany by Schroeter (**1885**), on *C. scheuchzeri* in Switzerland by Jaap (**1907**), and on *C. rotundifolia* in Sweden by Hammarlund (**1932**).

Synchytrium sp. on *Parnassia fimbriata*

Resting spores usually solitary, not filling host cell completely, subspherical to spherical, 119–168 μ, or ovoid, 110–135 × 128–166 μ, with an amber, smooth, wall, 4–4.5 μ thick, and light-yellow content; enveloping residue sparse, germination unknown.

Compositely monogallic, resting-spore galls abundant on petioles and upper surface of leaves, usually separate and scattered, sometimes crowded and confluent, predominantly dome-shaped or almost hemispherical on surface of leaf with a fairly broad apical depression, 216–258 μ high by 270–360 μ broad, base embedded in leaf and often causing opposite side of leaf to bulge out; sheath cells as small as or smaller than normal leaf cells and with fairly thick walls.

On *Parnassia fimbriata*, Glacier Nat. Park, Montana, U.S.A. (leg. M. E. Jones, 7–12–1910; spec. in Farlow Herb., Harvard Univ.).

This species, which was identified by Vera Miller as *S. aureum*, is smaller than the one I described (**1956d**) on the same host from Washington, and looks quite different in cross sections on the host leaf. The galls are less conspicuous with a thicker sheath of small cells and lack the rosette of elongate to clavate cells around the apex or crater which is so conspicuous in the Washington species. Also, in the latter species the sheath cells are very thick-walled and greatly enlarged in contrast to those of the Montana fungus. The latter fungus appears to stimulate the epidermal palisade and mesophyll cells and their derivatives to divide frequently without much enlargement. Since both fungi occur on the same host these differences in host reaction are significant and suggest that the fungi may be different. The fungus from Montana resembles more closely the one I (**1956a**) described on *Parnassia parviflora* from Canada.

In addition to the species examined and described above, mention is made here of the occurrence of *Synchytrium potentillae* and *S. myosotidis* on new and unreported hosts. *Synchytrium potentillae* was found by Dr. C. G. Shaw when he examined specimens of *Potentilla* in the

herbarium at Washington State College, and he kindly sent me this material for identification. These new hosts are: *Potentilla diversifolia*, Lewis and Clark Co., Montana (leg. C. L. Hitchcock, 7–4–1948; spec. no. 38933); *P. glandulosa*, Strawberry Mts., Grant Co., Oregon (leg. W. C. Cusick, 7–18–1910; spec. no. 38979), and *P. glaucophylla*, Burrows Mts., Mt. Ranier Nat'l Park, Washington (leg. J. B. Platt, 8–17–1919; spec. no. 38940). Included in the material from Dr. Shaw was *Synchytrium myosotidis* on *Cryptantha intermedia* from the San Carlos Range, San Benito Co., California (leg. Constance and Morrison, 5–23–1938; spec. no. 36382).

SUMMARY

Three species of *Synchytrium*, which were formerly identified as *S. fulgens* and *S. aureum*, are diagnosed and described as new species. *Synchytrium linariae* and *S. echinulatum* are long-cycled and develop prosori, sori, sporangia and resting spores in succession. They are, accordingly, placed temporarily in the subgenus *Microsynchytrium*, pending discovery of the manner by which their resting spores germinate. *Synchytrium davisii*, which is short-cycled and develops only resting spores, is included in the subgenus *Pycnochytrium*. In addition nine unidentified species are described on new hosts from Colorado, Montana, Oregon and Washington, U.S.A., and France.

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A NEW SPECIES OF PLAGIOSTOMA ASSOCIATED WITH A LEAF DISEASE OF HYBRID ASPENS

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(WITH 1 FIGURE)

In a plantation of hybrid aspens, located at Stiles' Corner near Petersham, Massachusetts, a severe outbreak of leaf diseases was reported by Scott S. Pauley in the summer of 1954. The plantation had been established in 1949 by the Maria Moors Cabot Foundation for Botanical Research of Harvard University, on land of the Quabbin District, Metropolitan District Commission. The material used in the planting was 1-0 seedlings representing 23 F_1 aspen progenies, derived from clones selected from various geographical sources. Nineteen of the progenies were from intraspecific crosses of clones of quaking aspen (*Populus tremuloides* Michx.); 2 from intraspecific crosses of clones of bigtooth aspen (*P. grandidentata* Michx.); and 2 from interspecific crosses of quaking aspen × bigtooth aspen. The plantation was laid out in square plots composed of 9 seedlings of a progeny in 3 rows, with 3 replications of each plot in randomized plantings.

Infection early in the spring by *Ciborinia whetzelii* Seaver caused extensive browning of the leaves and the production of sclerotia on progenies from intra- and interspecific crosses with *Populus tremuloides*. Early in September, on trees of the same progenies, many leaves that had escaped the *Ciborinia* infection showed small scattered reddish spots and yellowing of the leaves from the tip and margin inward between the veins. The discoloration spread rapidly, usually involving the entire leaf blade, changing to a conspicuous reddish brown and then to a dense chocolate brown. The midrib and the veins remained green for some time, but eventually veins and petioles became discolored.

The affected leaf tissue contained an abundance of hyaline hyphae, also small subcuticular acervulus-like structures with non-germinable

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subglobose to elliptic hyaline continuous spores. Spherical masses of mycelium within the leaf tissue suggested primordia of perithecia. In the spring of 1955, collections of overwintered fallen leaves showed numerous perithecia, horizontal in the leaf tissue, with lateral beaks piercing the lower leaf surface (FIG. 1) and 1-septate unequal-celled ascospores.

FIG. 1. Perithecium of *Plagiostoma populi* showing lateral beak piercing the lower leaf surface, and the asci, × 320.

The essential characters of the fungus are those of the Gnomoniaceae as defined by von Arx (**1951**, p. 265). In the horizontal perithecia, without clypeus, with lateral ostiole and thin-walled asci with a conspicuous apical ring, the fungus agrees with *Plagiostoma* Fckl., differing from the typical species of the latter only in the unequally-septate spores. No previously described species of that genus corresponds in all respects with the aspen fungus, and it is here described as a new species.

Plagiostoma populi sp. nov.

Perithecia non clypeata, singula, dense disposita, primum in foliis tote immersa, ellipsoidea, e parietibus crassis fuscis densis composita, 150–200 μ longa, 100–150 μ lata, 50–100 μ alta; diu clausa, demum rostro conico laterali ad perpendiculum emer-

genti, 40–50 μ longo, 25–30 μ in diam., intus periphysibus subhyalinis vel pallide brunneis munito praedita; asci horizontales, tenui-tunicati, breve stipitati, mox e pariete peritheciali liberati et in massa compacta cavitatem implentes, 2–6 spori, plerumque 4-spori, fusoideo-clavati, annulo apicale ornati, 35–40 × 10–12 μ; ascosporae hyalinae, ellipsoideo-clavatae, 11–13 × 4–6 μ, ad basim uniseptatae, cellula inferiori 2–3 μ in longitudinem et diametrum; paraphyses hyalinae evanescentes.

Perithecia without stroma, single, dense but not confluent, occupying large areas of the leaf or sometimes the complete leaf blade, embedded between the upper and the lower surface and occupying nearly the entire thickness of the leaf, ellipsoid, horizontally depressed, thick-walled, dark brown, the wall composed of several layers of densely packed, dark brown cells, the tissue paler and looser within, 150–200 μ long, 100–150 μ wide, and 50–100 μ high, for a long time remaining completely closed, at length opening by a conical lateral beak which pierces the lower leaf surface at right angles, 40–50 μ long, 25–30 μ in diameter, lined with pale brown or subhyaline periphyses; asci developing horizontally from the end of the cavity opposite the ostiole, thin-walled, with a short, very delicate, early evanescent stipe, soon freed from the perithecial wall and filling the perithecial cavity in a compact mass, 2–6-spored, usually 4-spored, fusoid-clavate, broadest near the center, narrowed at the apex and showing a conspicuous apical ring, 35–40 × 10–12 μ; ascospores hyaline, ellipsoid-clavate, 11–13 × 4–6 μ, 1-septate near the base, the basal cell 2–3 μ long and about the same in diameter; paraphyses hyaline, filiform, evanescent.

On overwintered leaves of Populus hybrids. TYPE on *Populus tremuloides* × *P. grandidentata* (progeny no. 11), Petersham, Massachusetts, May 11, 1955, coll. S. S. Pauley; deposited in the National Fungus Collections, Plant Industry Station, Beltsville, Maryland, and an isotype in Farlow Herbarium, Harvard University, Cambridge, Massachusetts.

In von Arx's key to the genera of the family Gnomoniaceae, p. 266, the aspen fungus would fit into *Plagiostomella* Hoehn., which is, however, a genus of doubtful status. It was erected in 1918 (Hoehnel **1918**, p. 52) for the one species of *Plagiostoma* Fckl. having unequally-septate spores. Unfortunately, Hoehnel named as type of his genus a fungus which he had not studied, relying on erroneous descriptions of *Plagiostoma petiolicola* Fckl. by Schroeter and Winter. Klebahn's studies (**1918**) showed that the spores of this species are septate, not at the base as described by Schroeter and Winter, but nearer the apex. In 1919 Hoehnel (**1919**, p. 131) therefore changed the type of his genus from *P. petiolicola* to *P. carpinicola* Hoehn., the second species named in 1918 when he described the genus. There appears, however, to be

no justification in the International Code for such a change of type species by the author of a genus.

Von Arx (**1951**) considered the original type of *Plagiostomella* selected by Hoehnel to be a *Plagiostoma,* in which genus he included the species having equally septate ascospores and, in addition, this one species in which the spores are septate above the center. For the species with spores septate near the base, he recognized *Plagiostomella* Hoehn., as typified by *P. carpinicola,* the second type proposed by the author. If the original type is retained, however, in accordance with the International Code, *Plagiostomella* is a synonym of *Plagiostoma.*

Since the status of *Plagiostomella* is questionable and since the writers do not wish to propose a new generic name to be used for *Plagiostomella carpinicola* Hoehn. and the new species on aspen, it seems advisable to broaden the concept of *Plagiostoma* to include those species which have spores unequally-septate near the base, as well as those with equally septate spores and with spores septate above the middle. We have therefore described our fungus on *Populus* as a *Plagiostoma. Plagiostoma populi* differs from *Plagiostomella carpinicola* Hoehn. in having shorter and broader asci and ascospores, as well as in its occurrence on a different host genus.

The significance of the acervulus-like structures occurring on the upper surface of the affected leaves and preceding the development of the perithecia has not been determined. Therefore a description of their characteristics is not included in the species description.

Sterilized pieces of infected leaves with mature perithecia were transferred to plates of malt or potato-dextrose agar media, but no growth resulted. Ascospores were readily isolated from crushed perithecia, but these did not germinate on the artificial media or in distilled tap water. The difficulty in obtaining germination of ascospores of species in closely related genera of the Gnomoniaceae, such as *Gnomonia* and *Gnomoniella,* has been reported by Klebahn (**1919**) and Miles (**1921**). Facilities for the inoculation of the F_1 progenies of aspen with a suspension of ascospores of *Plagiostoma populi* were not available.

Inspection of the aspens in September 1954 and 1956 showed severe infection by *Plagiostoma populi* on trees of progenies from interspecific crosses of one female clone of *Populus tremuloides* with 2 clones of *P. grandidentata.* This same female clone was also a parent in 12 intraspecific crosses of *P. tremuloides,* all of which included progenies that were slightly susceptible. The progeny of one other similar cross was free from infection. Four other female clones of *P. tremuloides* were used in 6 intraspecific crosses. Progenies of 3 of these crosses showed

no infection and the remainder were very slightly susceptible. One female clone of *P. grandidentata* was crossed with 2 male clones of the same species. Trees of the resulting progenies were not infected. Inspection of trees of both species growing naturally in the vicinity of the plantation revealed no infection. Therefore, the origin of *Plagiostoma populi* is not known.

The progenies from interspecific crosses which were most seriously attacked by *Plagiostoma populi* in September, 1956, were those that had been heavily infected by *Ciborinia whetzelii* in the spring and early summer. On some trees the combination of the two fungi resulted in the destruction of about 90% of the season's foliage. The amount of infection and damage by *P. populi* on the trees that were rated as slightly susceptible was difficult to determine. Many leaves that were infected by *P. populi* were attacked also by other parasitic fungi, such as species of *Melampsora* and *Marssonina*, thus resulting in atypical symptoms. Moreover, leaves that had been partially discolored by *Ciborinia* infection in the spring were frequently attacked by *P. populi* later in the season, and completely killed. It is probable, therefore, that infection by *P. populi* alone causes no serious retarding of the growth of the hybrid aspens, but is a contributing factor in the premature defoliation.

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AN IRREGULAR AND UNUSUAL FORMATION OF MYCELIAL MATS BY CERATOCYSTIS FAGACEARUM [1]

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(WITH 9 FIGURES)

Ceratocystis fagacearum (Bretz) Hunt produces a unique specialized structure called a mycelial mat (**2**, **3**, **4**). Apparently this is the only species of the genus, in fact of all the fungi, which produces it. The so-called "mycelial mat or felt" of the decay fungi is only vegetative in nature, and is quite different in composition and function, as well as position. The structure as found in *C. fagacearum* consists of a central, black, furrowed, gelatinous sclerotium-like pad or cushion, surrounded by a stromatic or mycelial growth (FIG. 1). The central, furrowed pad is considerably thicker than the mycelial portion of the mat. In addition, the mat, in all reported observations (**2**, **3**, **4**, **7**, **8**, **11**, **13**), develops as one mat on the outer surface of the wood, and one exactly similar mat on the inner surface of the bark as a mirror image structure (FIGS. 1, 2). As the pad develops it exerts considerable pressure on the bark, causing a bulge and forming a moist chamber which is excellent for the development of the sporulating mycelial portion. The continued growth of the pad eventually ruptures the bark. The mycelial portion bears endoconidia in large numbers. Since the mat produces an odor similar to fermenting apples, insects are attracted after the crack has formed. In this fashion, the structure functions as a mechanism not only for the liberation of spores, but also as a method of diploidization (**7**), since the endoconidia can function as sex cells, inducing ascospore formation. According to all previous reports endoconidia and perithecia have been found only in the mycelial portion of the mat. The hyphae in this portion form a plectenchyma of narrow

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interwoven hyphal strands (**11**). The hyphae of the sclerotium-like central pad consist of a pseudoparenchyma of greatly enlarged cells (**3**). Endoconidia and perithecia have not been found on the pad. This would be expected in the light of their interpreted function and since one pad presses against the other as they develop. However, loose aerial hyphae sometimes grow abundantly on the outer edges forming a definite, easily discerned border around the pad.

Factors influencing mycelial mat formation are being studied on artificially inoculated trees as well as on naturally infected trees. To date, 765 mats have been examined on 51 of 209 inoculated trees. An abnormal pad formation in an unusual position was observed on a single inoculated black oak tree in August, 1956.

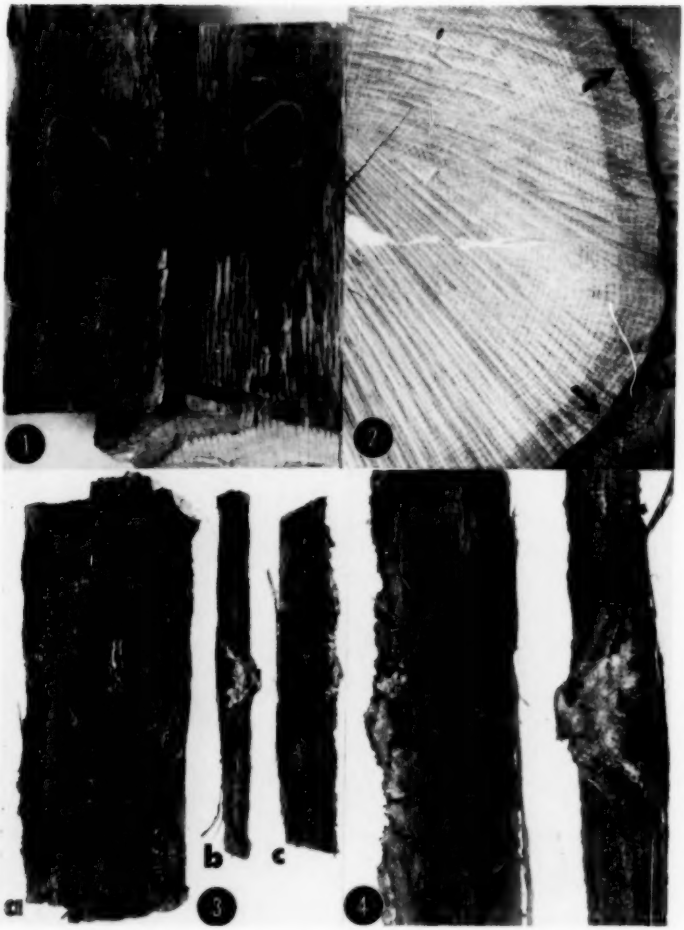
In eight locations on the tree, pad tissue only was produced. Furthermore, the pads were single and formed partially imbedded in the bark of the oak tree (FIGS. 3, 4). The bark to the outside of the pad had cracked (FIG. 3) and the characteristic odor of a typical mycelial mat was detected. The individual pads were of average size, $7 \times 20 \times 30$ mm. No endoconidia were found on the pad. Tissue isolations were made in malt extract agar and pure cultures characteristic of *C. fagacearum* were obtained from the pads.

Thirteen normal mats also formed on this tree in the cambial region, developing as mirror images on the outer surface of the wood and the inner surface of the bark.

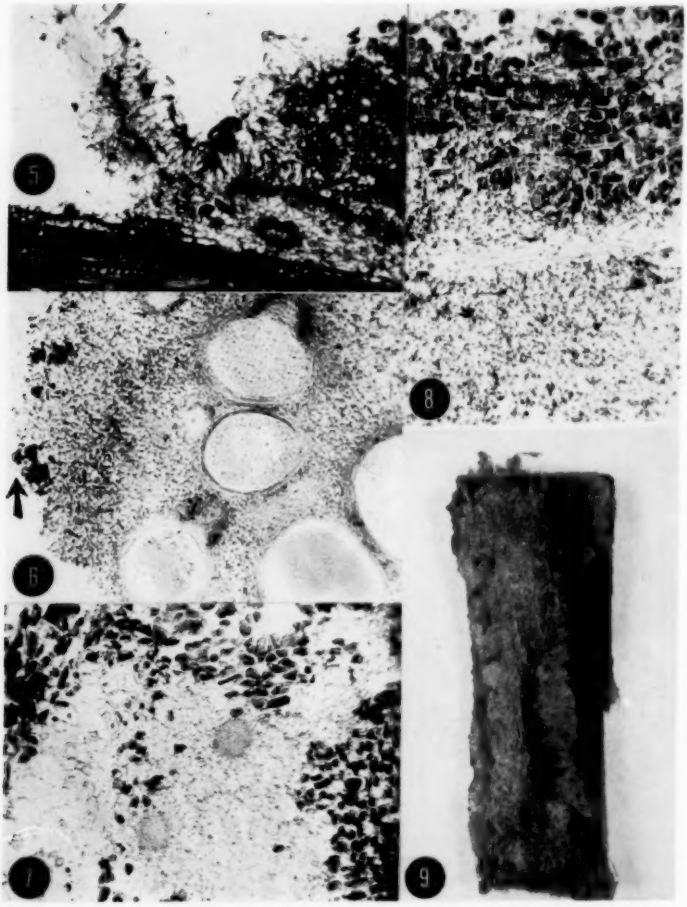
Because of the unusual nature and position of the pads, histological studies were made of their structure.

Small samples were cut for convenient handling, and killed and fixed in formalin-aceto-alcohol (FAA). The samples were washed in running tap water, dehydrated by the n-butyl alcohol method (**10**) and imbedded in "Fisher Tissuemat." The safranin 0 and fast green staining technique (**6**) was employed. The structure of normal mats was also studied in a similar manner for comparison.

As previously reported (**3**), the pad of a normal mat was found to be a pseudoparenchyma of enlarged cells, and the mycelial portion a prosenchyma (FIG. 5). The internal composition of the irregular pad (FIG. 6) consists of prosenchyma instead of the pseudoparenchyma of a normal pad. In addition, large rounded bodies were observed in most of the sections. Invasion of the secondary phloem surrounding the irregular pad was much more extensive than that occurring in normal mycelial mat formation. FIG. 7 shows hyphae in the phloem about 5 mm away from the irregular pad. The mycelium is a very loose



FIGS. 1–4. *Ceratocystis fagacearum*. 1. Normal mycelial mat of *C. fagacearum* developed as mirror images on inner surface of bark and outer surface of wood. Note the crack in the bark. 2. Section through oak stem to show how the mycelial mat develops between the bark and wood. 3. Irregular pad formation of *C. fagacearum* in the bark of oak. a. Left, crack in bark. b. Sectioned bark. c. Bark turned to show that pad formed in the bark and not on inner surface. 4. Enlargement of irregular pad to show formation in the bark.



FIGS. 5–9. *Ceratocystis fagaccarum*. 5. Vertical section through pad and mycelial portion of a normal mycelial mat. Pad is pseudoparenchyma and mycelial portion is a prosenchyma, × 140. 6. Mycelium of the irregular pad. The arrow indicates the outer margin of pad which was directly below the crack in the bark. Note the rounded hyphal bodies, × 140. 7. Hyphae in bark, about 5 mm from the irregular pad. Note the rounded compact hyphal bodies. The mycelium has replaced a considerable portion of secondary phloem which is bulged outward, × 140. 8. Hyphae of *C. fagaccarum* developing in the secondary phloem, about 3 mm from the irregular pad, × 140. 9. *Basidiobotrys* sp. in the bark of oak.

prosenchyma, replacing the secondary phloem. Two smaller rounded bodies were observed in this section. The majority of sections revealed the presence of the rounded bodies; however, FIG. 8 illustrates extensive hyphal development without the rounded bodies. The exact nature of the rounded bodies is unknown; however, similar rudimentary or abortive perithecia also developed in a "selfed" culture of *C. fagacearum*. *C. fagacearum* is an hermaphrodite consisting of two self-sterile but cross-fertile compatibility types. Abortive perithecia have been obtained in culture when certain isolates have been "selfed," spermatized with their own endoconidia (**5**). Their similarity to the rounded bodies of the irregular pad is worth noting. Distinct compact structures, consisting of two or more large cells surrounded by several layers of smaller cells, were reported in the stroma (**12**) of mycelial mats of *C. fagacearum* on northern pin oak. No suggestion was made as to their possible nature.

Since these irregular pads were found on only one tree and since less than half of the total mats formed on the tree were of this peculiar composition and in the irregular position, such formation would appear to be quite rare. Furthermore, hundreds of mats on naturally infected trees have been seen and in no instance were pads or mats found in the bark. The development of pad tissue only has been reported before (**4**), but such pads have been found only under uncracked bark and in the cambial region, as mirror images on bark and wood. They were interpreted to be initial stages in mat formation (**4**).

Several other fungi which reproduce within and on the bark soon after the death of the trunks and branches superficially resemble the pads of *C. fagacearum*, especially if the latter have started to decline and have lost their watery consistency. A very interesting hyphomycete, identified as a species of *Basidiobotrys* Höhnel (**1**), was found on one red oak stem, covering an area approximately 6 × 3 inches. Macroscopically, the growth consisted of a basal dark portion covered by a very fine, scurfy to pulverulent, light gray development of conidiophores of *Basidiobotrys* (FIG. 9). The growth was on the inner bark, below the older ridged bark. One species is described in Saccardo (**9**) as *Xylocladium clautriavii* (Pat.) Syd. (*Basidiobotrys clautriavii* (Pat.) Höhn.). The sizes of the conidia, vesicle and clavae (short thick cells bearing the conidia) of this species on oak are quite different from those given by Saccardo (**9**) for *X. clautriavii*. Barnett (**1**) cites *B. griseus*, but no description of this species could be found. Other fungi found were: *Nummularia builliardii* Tul., *Hypoxylon atropunctatum* (Schw.)

Cooke, *Diatrype stigma* (Hoffm.) DeNot., and *Bulgaria inquinans* (Pers.) Fr.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY
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SOME NEW GRASS SMUT RECORDS FROM THE WESTERN STATES. III.[1, 2]

JACK P. MEINERS AND GEORGE W. FISCHER[3]

Continued surveys have been made to determine the extent of the grass bunts (*Tilletia* spp.) and their relation to the wheat bunt problem in the Pacific Northwest. Collecting trips to obtain grass smuts for research purposes in recent years, have, incidentally, established a number of new records of host range and geographic distribution. These records given in this account are in addition to the new records pertaining to dwarf bunt (*T. contraversa* Kuehn) on grasses and rye reported in 1955 and 1956 (**2**, **3**, **4**). Specimens representing these records have been deposited in the Mycological Herbarium of the Department of Plant Pathology, State College of Washington (WSP Nos.) or in the National Fungus Collections of the Agricultural Research Service, U. S. Department of Agriculture (BPI Nos.).

TILLETIA ASPERIFOLIA Ell. & Ev.

New state record: Wyoming: Mary Bay, Yellowstone National Park, on *Muhlenbergia filiformis* (Thurb.) Rydb., August 31, 1956, Coll. R. Sprague and G. W. Fischer, WSP No. 44348, BPI No. 85978.

TILLETIA BROMI-TECTORUM J. Urr.

New host: *Bromus sterilis* L., Pullman, Wash., May, 1956, Coll. G. W. Fischer, WSP No. 44350, BPI No. 85988.

[1] Cooperative investigations of the United States Department of Agriculture, Crops Research Division, Agricultural Research Service, and the Agricultural Experiment Stations of Idaho, Oregon, and Washington. Scientific Paper No. 1602, Washington Agricultural Experiment Stations, Pullman, Washington. Projects 183, 1191, 1194. Supported in part by funds provided for Medical and Biological Research by the State of Washington Initiative Measure 171.

[2] Parts I and II of this series appeared in Mycologia **30**: 385–395, 1938 and **43**: 67–77, 1951, respectively.

[3] Plant Pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Plant Pathologist, Washington Agricultural Experiment Stations, Pullman, Washington.

New state record: Wyoming: Mary Bay, Yellowstone National Park, on *Bromus tectorum* L., August 31, 1956, Coll. G. W. Fischer and R. Sprague, WSP No. 44349, BPI No. 85975.

Actually, this is the first official recognition of this smut in the western hemisphere. However, the same smut has been reported earlier from several of the western states under the tentative designation of *Tilletia caries* (D.C.) Tul. (**1**). A more complete account of the occurrence and life history of this smut will appear elsewhere.

TILLETIA CEREBRINA Ell. & Ev.

New state record: Idaho: Cascade, on *Deschampsia danthonioides* (Trin.) Munro ex Benth., July 31, 1954, Coll. J. P. Meiners and L. H. Purdy, WSP No. 44207.

TILLETIA DECIPIENS (Pers.) Koern.

New national record: On *Agrostis palustris* Huds. (Seaside creeping bent) and *A. tenuis* Sibth. (colonial bent, highland bent, etc.), eastern Polk County, Oregon, in 1953 seed samples. Comm. Mrs. Grace Cole Fleischman. On *Agrostis tenuis* Sibth., Long Beach, Washington, in 1953 seed samples; Comm. Mrs. Grace Cole Fleischman.

Although long known and very widespread in Europe, this is the first report of this bunt from the United States and only the second from North America, the first having been from Nova Scotia. The occurrence of *T. decipiens* in bentgrass seed samples from commercial plantings indicates the need for alertness to attempt to prevent it from becoming a problem in bentgrass seed production.

TILLETIA FOETIDA (Wallr.) Liro

New host: *Elymus canadensis* L., Pullman, Wash., July 15, 1955, Coll. J. P. Meiners. Apparently this is the first report of the natural occurrence of this widespread parasite of wheat on a non-cereal graminicolous host. Inadvertently, the entire collection was used as inoculum to determine its race identity and none remained for herbarium purposes. Incidentally, the collection proved to be Race L-4.

TILLETIA FUSCA Ell. & Ev.

New host: *Festuca reflexa* Buckl., Boise, Idaho, July 19, 1955, Coll. J. P. Meiners and L. H. Purdy, WSP No. 44205, BPI No. 85928; Ritzville, Wash., Sept. 7, 1955, Coll. J. P. Meiners and J. T. Waldher, WSP No. 44208.

TILLETIA GUYOTIANA Hariot

New state records: Montana: Bozeman, on *Bromus japonicus* Thunb., Aug. 8, 1954, Springhill locality, Coll. J. P. Meiners and L. H. Purdy, WSP No. 44204; Oregon: Elgin, on *Bromus brizaeformis* Fisch. and Mey., July 8, 1954, Coll. J. P. Meiners and C. S. Holton, WSP No. 44198; on *Bromus commutatus* Schrad., July 28, 1954, WSP No. 44201; on *Bromus japonicus* Thunb., Aug. 26, 1955, Coll. J. P. Meiners and J. T. Waldher, WSP No. 44203; on *Bromus racemosus* L., July 8, 1954, Coll. J. P. Meiners and C. S. Holton, WSP No. 44200; Utah: Logan, on *Bromus japonicus* Thunb., July 21, 1955, Coll. J. P. Meiners and L. H. Purdy, WSP No. 44202.

TILLETIA SCROBICULATA G. W. Fisch.

New state records: Oregon: Elgin, on *Poa secunda* Presl, Aug. 22, 1956, Coll. J. P. Meiners, WSP No. 44197; Washington: Asotin Co. on *Poa secunda* Presl, June 24, 1956, Coll. G. W. Fischer, Det. R. Duran and G. W. Fischer, WSP No. 44351, BPI No. 85929.

UROCYSTIS AGROPYRI (Preuss) Schroet.

New host: On *Agropyron bakeri* E. Nels., Chelan County, Washington, June 20, 1951, Coll. and Det. R. Sprague, WSP No. 44352, BPI No. 85926; *Alopecurus alpinus* J. E. Smith, Targhee Pass, Idaho, September 1, 1956, Coll. G. W. Fischer and R. Sprague, WSP No. 44356, BPI No. 85981; *Bromus pumpellianus* Scribn.; Bald Pass, Big Horn National Forest, Wyoming, August 21, 1954, Coll. G. W. Fischer, WSP No. 44357, BPI No. 85906; on *Festuca idahoensis* Elmer, Upper St. Mary's Lake, Glacier National Park, Montana, August 19, 1952, Coll. G. W. Fischer, WSP No. 44360, BPI No. 85953.

New state records: Colorado: Rocky Mountain National Park, on *Agropyron trachycaulum* (Link) Malte, August 22, 1954, Coll. G. W. Fischer, WSP No. 44355, BPI No. 85919; Idaho: Rexburg, on *Agropyron smithii* Rydb., September 1, 1956, Coll. G. W. Fischer, WSP No. 44353, BPI No. 85984; Targhee Pass, on *Calamagrostis canadensis* (Michx.) Beauv., September 1, 1956, Coll. R. Sprague and G. W. Fischer, Det. H. C. Govindu, WSP No. 44358, BPI No. 85985; Montana: St. Mary's Lake, Glacier National Park, on *Elymus glaucus* Buckl., August 28, 1956, Coll. G. W. Fischer and R. Sprague, WSP No. 44359, BPI No. 85937; Upper St. Mary's Lake, Glacier National Park, on *Agropyron spicatum* (Pursh) Scribn. & Sm., August 19, 1952, Coll. G. W. Fischer, WSP No. 44354, BPI No. 85949; Oregon: Flora,

on *Poa secunda* Presl, June 26, 1956, Coll. J. P. Meiners and J. T. Waldher, WSP No. 44199; Wyoming: Bald Pass, Big Horn National Forest, on *Glyceria striata* (Lam.) Hitchc., August 21, 1954, Coll. G. W. Fischer, WSP No. 44361, BPI No. 85902.

UROCYSTIS FRASERI Clint. & Zundel

New state record: Wyoming: Bald Pass, Big Horn National Forest, on *Stipa columbiana* Macoun; August 21, 1954, Coll. Geneva R. Fischer, WSP No. 44362, BPI No. 85889.

USTILAGO BULLATA Berk.

New state record: Montana: Depuyer, on *Elymus macounii* Vasey, August 29, 1956, Coll. R. Sprague and G. W. Fischer, WSP No. 44363, BPI No. 85942.

USTILAGO JACKSONII Zundel & Dunlap

New host: On *Stipa columbiana* Macoun; Bald Pass, Big Horn National Forest, Wyoming, August 21, 1954, Coll. Geneva R. Fischer, WSP No. 44364, BPI No. 85894.

New state record: Wyoming: Bald Pass, Big Horn National Forest, on *Stipa lettermanii* Vasey, August 21, 1954, Coll. G. W. Fischer, WSP No. 44365, BPI No. 85892.

USTILAGO MACROSPORA Desm.

New state records: Montana: Upper St. Mary's Lake, Glacier National Park, on *Elymus glaucus* Buckl., August 18, 1952, Coll. G. W. Fischer, WSP No. 44379, BPI No. 85954; Wyoming: Mary Bay, Yellowstone National Park, on *Phalaris arundinacea* L., August 31, 1956, Coll. R. Sprague and G. W. Fischer, WSP No. 44366, BPI No. 85974.

USTILAGO SPEGAZZINII Hirschh. var. AGRESTIS (Syd.) G. W. Fisch. & Hirschh.

New host: On *Elymus junceus* Fisch., Soil Conservation Service Nursery, Pullman, Washington, June 14, 1955, Coll. S. M. Deitz, WSP No. 44380.

New state records: California: San Mateo, on *Agropyron repens* (L.) Beauv., June, 1953, Coll. I. J. Campbell, WSP No. 44381, BPI No. 85869; Washington: Moses Lake, on *Stipa comata* Trin. & Rupr., June, 1954, Coll. G. W. Fischer.

USTILAGO STRIIFORMIS (Westend.) Niessl

New host: on *Alopecurus alpinus* J. E. Smith, Targhee Pass, Idaho, September 1, 1956, Coll. G. W. Fischer and R. Sprague, WSP No. 44369, BPI No. 85981; on *Bromus pumpellianus* Scribn., Bald Pass, Big Horn National Forest, Wyoming, August 21, 1954, Coll. G. W. Fischer, WSP No. 44370, BPI No. 85906; on *Calomagrostis neglecta* (Ehrh.) Gaertn., Mey., and Schreb., St. Mary, Mont., August 28, 1956, Coll. R. Sprague and G. W. Fischer, WSP No. 42786; on *Elymus chinensis* (Trin.) Keng., Soil Conservation Service Nursery, Pullman, Washington, June 12, 1953, Coll. J. P. Meiners, WSP No. 44371, BPI No. 85925; on *Hesperochloa kingii* (S. Wats.) Rydb., Fort Collins, Colorado, July 12, 1956, Coll. and det. G. B. Cummins, WSP No. 44374, BPI No. 85989; on *Poa nevadensis* Vasey, Austin, Nevada, July 30, 1950, Coll. G. W. Fischer and R. Sprague, WSP No. 44376, BPI No. 85712; on *Puccinellia distans* (L.) Parl., Nairada, Montana, June 30, 1955, Coll. and det. G. B. Cummins, WSP No. 44377, BPI No. 85990.

New state records: Colorado, Black Hawk, on *Agrostis alba* L., August 28, 1954, Coll. G. W. Fischer, WSP No. 44367, BPI No. 85920; Idaho: Gibbensville, on *Trisetum spicatum* (L.) Richt., July 22, 1955, Coll. J. P. Meiners, WSP No. 44378, BPI No. 85932; Montana: Logan Pass, Glacier National Park, on *Poa alpina* L., August 19, 1952, Coll. G. W. Fischer, WSP No. 44375, BPI No. 85961; Yakt, on *Agrostis alba* L., August 27, 1956, Coll. G. W. Fischer and R. Sprague, Det. H. C. Govindu, WSP No. 44368, BPI No. 85986; Yakt, on *Festuca occidentalis* Hook., August 27, 1956, Coll. G. W. Fischer and R. Sprague, Det. H. C. Govindu, WSP No. 44372, BPI No. 85987; Washington: Umatilla National Forest, on *Poa secunda* Presl, July 8, 1956, Coll. J. P. Meiners, WSP No. 44206; Wyoming: Baldy Pass, Big Horn National Forest, on *Festuca ovina* L., August 21, 1954, Coll. G. W. Fischer, WSP No. 44373, BPI No. 85900.

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NOTES AND BRIEF ARTICLES

A DOUBLE-DISH METHOD OF CULTIVATING FUNGI

Although the two standard methods of cultivating fungi, on agar or in liquid medium, have had wide application, for certain purposes they are inadequate. In our present study of pleomorphisms in the dermatophyte *Trichophyton mentagrophytes*, it was necessary to have available a method of culture which would allow both the development of colony characters found in agar cultures and ease of separation of the fungus from its source of nutrient. Since neither of the two standard methods met both requirements, the applicability of a new technique, suggested to the writer by Dr. W. J. Robbins, was tested.

Essentially, it is a double-dish method; the outer plate contains the nutrient agar and the fungus is limited to the inner dish. The former is a 9 cm Petri dish containing nutrient agar. The inner dish consists of a disk cut from a roll of Visking [1] seamless cellulose tubing (inflated diameter $4\frac{1}{2}''$) and a lucite ring.[2] The cellulose membrane constitutes the bottom of the inner dish and the lucite ring serves as the side wall. The tubing is cut into sheets six inches square which become pliable when moistened. A lucite ring, inside diameter $2\frac{5}{8}''$, thickness $\frac{1}{4}''$, height $\frac{7}{16}''$, is then placed on a moistened sheet, and that portion of the sheet lying outside the ring is folded upwards. The upturned membrane is made fast to the outer surface of the ring with an elastic band, and the portion of the membrane projecting above the ring is trimmed away. FIG. 1 is an oblique view of the inner dish showing the lucite ring, elastic band, and membrane. The cellulose-lucite dish can be autoclaved in a Petri dish containing several ml of water.

When a culture is to be prepared, a sterile cellulose-lucite dish is placed upon the surface of the nutrient agar in the outer Petri dish and the fungus inoculated directly upon the cellulose membrane. In our experience with *T. mentagrophytes* the subsequent development of a normal colony demonstrates that sufficient nutrient and water diffuse from the agar through the membrane. The fungus does not attack the cellulose nor do any hyphae penetrate it. Consequently, for this species

[1] The Visking Corporation, Chicago 38, Illinois.

[2] The lucite rings were provided by the generosity of Charles Pfizer and Co., Brooklyn, New York. Somewhat smaller rings were purchased from Ward's Natural Science Establishment, Inc., Rochester, New York.

the above method allows both the development of colony characters found in agar cultures and ease of separation of fungus and nutrient source.

The method permits experiments in which a fungus colony can be transferred *in toto* to fresh medium at required intervals. It is possible also to study the relation between the development of an individual colony and various nutrient environments by transferring the inner dish to various agar media at given intervals.

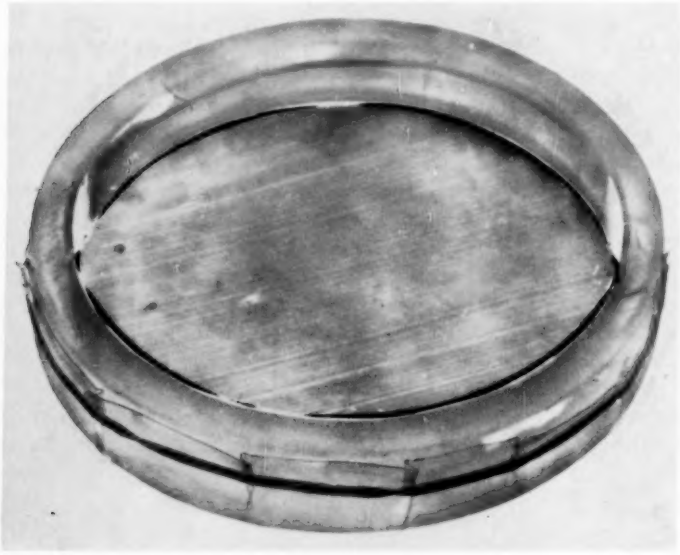

FIG. 1. Inner dish as prepared for autoclaving.

The method may also have use in dry weight determinations since entire mycelia can be scraped from the surface of the cellulose membrane with a sharp razor blade and the dry weight measured in the usual way. —GEORGE N. BISTIS, The New York Botanical Garden, Bronx Park, New York 58, N. Y.

THE POSSIBLE INFECTION OF THE HUMAN BODY WITH CERCOSPORA APII

C. W. Emmons *et al.* (Mycologia **49**: 1–10. 1957) describe and illustrate a disfiguring eruption on the face of an Indonesian boy. They attribute this malformation to the effects of *Cercospora apii*.

I disagree with their identification of the causal agent and with their conclusions for the following reasons:

1. The fungus as it grows in culture does not resemble cultures of any Cercospora species I have studied. (A culture was generously provided by Dr. Emmons.)

2. The shape of the conidia (see their Fig. 3, D) is unlike any of those found in the Cercosporae that I have investigated.

3. The authors state that the conidia of their fungus are pale brown. *Cercospora apii* never shows any color in the conidia.

4. The bases of the conidia of their fungus usually are convex. This does not hold true for *Cercospora apii*, in which the base of the conidium is plainly truncate.

5. The authors do not mention any attempts at inoculating celery, but on inoculation leaf spots were produced on lettuce, potato, and tomato. *C. apii*, so far as can be determined, infects only celery.

6. The true *C. apii* is worldwide and in many instances appears in epidemic form, yet its man-infecting quality has never been discovered until this particular case was reported.

The authors seem to base most of their statements on an article prepared by Johnson and Valleau (Phytopathology **39**: 763–770. 1949) who list *Cercospora* species with colored or hyaline conidia, fasciculate or non-fasciculate conidiophores, and other diverse characters as being the same. Even if the statements of these two authors were correct, the fungus found in the skin of the Indonesian boy would still not be a *Cercospora*, judging from the characters which I associate with this genus.—CHARLES CHUPP.

MYCOLOGIA

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR THE YEAR ENDED JUNE 30, 1957

Cash receipts		
Joint Funds		
Members' subscriptions (Mycological Society)	$ 3,525.00	
Other subscriptions	7,449.97	
Sales of V. 25 and later	928.85	
Excess pages and illustrations	427.85	$12,331.67
Special Funds		
Sale of V. 1–24 and Index	851.43	
Income from endowment	950.00	1,801.43
Total receipts		$14,133.10
Cash disbursements		
Printing and distribution	$11,411.87	
Reprinting	929.26	
Office expense	447.62	
Total expenditures		$12,788.75
Excess of receipts over expenditures		1,344.35
Unexpended balance July 1, 1956		5,050.13
Unexpended balance July 1, 1957		$ 6,394.48
Endowment July 1, 1956	$19,450.00	
Proportionate share of profits from sales of securities	$716.00	
Gift to endowment	500.00	1,216.00
Endowment July 1, 1957		$20,666.00

The above MYCOLOGIA funds are administered by The New York Botanical Garden, and the balances at June 30, 1957, are in agreement with the amounts shown in the financial statements of that organization which have been examined by Price, Waterhouse & Company.

REVIEWS

MEDICAL MYCOLOGY—LABORATORY MANUAL, by E. S. Beneke, 186 pp., 34 figs., 13 pl., partly col., Burgess Publishing Company, Minneapolis, 1957. Price, $4.00.

The upsurge of interest in medical mycology that began just prior to World War II has resulted in the publication of several books that have attempted to cover both the clinical and mycologic aspects of fungus diseases. Since most of these publications have been designed to meet the needs of the practicing physician, the emphasis generally has been upon the patient and his disease rather than upon the causative fungi and their characteristics. A manual specifically designed for the laboratory study of human pathogenic fungi has long been needed by technicians and students of medical mycology. For this purpose the present publication should be very useful.

Beneke's manual first introduces the student to the general characteristics of fungi and their classification. This is followed by a series of exercises dealing with the cultural and microscopic features of some of the more prevalent saprophytic fungi frequently encountered as contaminants in the laboratory. Familiarity with these species is necessary to avoid confusion with pathogens. In addition, laboratory work with non-pathogens develops proficiency in the handling of cultures and the microscopic examination of fungi before work is begun with infectious species. Small black and white photographs are used to illustrate the microscopic features of the saprophytes. However, the quality of reproduction or the magnification used is such that it is doubtful if many of the photographs will prove to be of value to the student.

The studies of the pathogenic fungi are introduced by a section on laboratory procedures. Here basic equipment for collecting clinical specimens is listed, along with methods for obtaining and examining specimens for the superficial and systemic mycoses. Mounting fluids, stains, media and animal tests are described for general and specific purposes.

Two factual errors were noticed in this section that are serious enough to merit mention: Blood Agar Base encourages macroconidial formation by *Trichophyton mentagrophytes* and *T. rubrum* at room temperature but not at 37° C as stated. Seeliger's dextrose-tween agar is best used to detect mycelial formation in yeast-like fungi, not for the development of chlamydospores by *Candida albicans*.

Following these introductory sections, 26 exercises describe the majority of the pathogenic fungi under the heading of the diseases that they cause. These sections are stylized, each giving a definition of the disease, a list of the etiological agents involved, a note on the geographic distribution and occurrence in lower animals, laboratory procedures for the collection of specimens, examination of clinical specimens and cultures. Questions pertinent to the materials studied are provided, along with selected references. Colored, and black and white illustrations depict the clinical aspects of certain of the diseases, the appearance of the etiologic agents in tissues and the cultural and microscopic features of the pathogenic fungi described. In many instances the colored illustrations are well reproduced but in others the color values are so far removed from reality that they are apt to be more misleading than useful. Especially poor are the colored photographs of colonies of *Aspergillus fumigatus, Monosporium apiospermum, Phialophora verrucosa, Hormodendrum pedrosoi, Trichophyton mentagrophytes, Microsporum gypseum* and *Epidermophyton floccosum.*

"The Characteristics of the Dermatophytes" and "The Characteristics of the Deep Mycoses" are tabulated on two long folded charts. The inclusion in the dermatophyte chart of the bacterium *C. tenuis,* the ascomycete *P. hortai,* and the actinomycete *N. minutissima* as well as organisms not in the genera Trichophyton, Microsporum and Epidermophyton seems inappropriate. This chart would be better entitled "The Characteristics of Fungi that Invade Keratinaceous Tissues."

A list of sources for media, cultures, equipment and visual aids, and a short glossary is also provided.

Scattered throughout the manual are numerous typographical errors that are indicative of hasty proofreading.

The manual, with its paper cover and spiral binding, is attractive. It is handy in size and the large sized type makes for easy reading. It should prove to be of great value to students embarking on the study of the fungi that cause human and animal diseases.—LIBERO AJELLO.

MAGYARORSZÁG KALAPOSGOMBÁINAK, by G. Bohus, Z. Kalmar and G. Ubrizsy. 512 pp., 29 pl. Akadémiai Kiadó, Budapest. 1951.

A foreword relates the present work to other mycological studies carried on in and published from Hungary. An introductory chapter describes biology, structure, chemistry of mushroom fungi; mycorrhizae; ecology; relation of mushroom fungi to plant associations; and herbarium techniques. A two-page key indicates the place of the agarics in the Basidiomycetes. They are placed in the Hymenomycetes, con-

trasted with the Gasteromycetes. The orders of Hymenomycetes include: Exobasidiales, Corticiales, Thelephorales, Clavariales, Hydnales, Polyporales and Agaricales. The Boletaceae and the Agaricaceae are the only families considered in the Agaricales and the Agaricaceae is divided into four subfamilies: Agariceae, Lactarieae, Hygrophoreae and Cantharelleae. The 46 genera of agarics which are recognized are keyed out. The generic treatment appears to be relatively conservative, and since the book is designed to be used by the average man the keys are probably not too complicated. For each genus which is treated a brief characterization is given, species keys are presented when more than one species is considered. The species are described tabularly giving Latin names, vernacular names, synonyms, cap description and size, stipe description and size, spore print and size characters, and habitat. More than 450 species are treated.—WM. BRIDGE COOKE.

HOUBY I, by Karel Cejp. 495 pp., 122 figs. Československé Akademie Věd. Praha, 1957.

This is the first of two volumes, the second of which will appear next year. In it the Myxomycetes, Phycomycetes and Ascomycetes are treated. The book is intended to serve both as a text of mycology and as a source book for mycological information. It is well illustrated with both photographs and line drawings, many of which are original; others are copies of previously published figures. The number of references to recently published work in the world literature indicates a surprising ability to keep abreast of the times on the part of workers with limited access to the world market. The work is in the Czech language and is reported to be the third European work of its kind, having been preceded by the works of Gäumann and Moreau.—WM. BRIDGE COOKE.

BIBLIOGRAPHIE DER PFLANZENSCHUTZ-LITERATUR, 1946–1947, by J. Bärner. xli + 460 pp. Biologische Bundesanstalt für Land- und Forstwirtschaft in Berlin-Dahlem. Verlag Paul Parey, Berlin. 1957. DM 44.50 (about $11.00).

This volume is the first of those planned to fill the gap in the "Bibliographie der Pflanzenschutz-Literatur" that was started in 1914 by Prof. Morstatt and carried through 1945 and then revived in 1950 by Dr. Bärner (Mycologia **48**: 615. 1956 and Mycologia **49**: 303. 1957). It carries 13,800 titles arranged as in the preceding volumes. Its characteristic thoroughness makes this series a valuable contribution to the bibliography of the field of plant pathology.—JOSEPH C. GILMAN.

MANUSCRIPT

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